

UNIVERSITY OF BRISTOL.



THE ANNUAL REPORT

OF THE

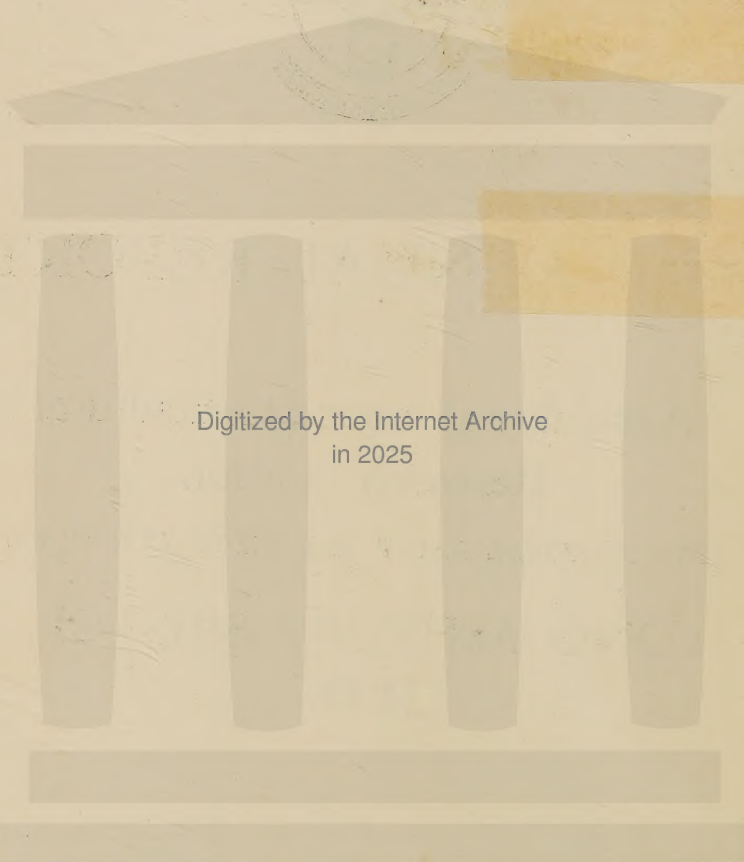
Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL,
1935.

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INTRODUCTION.

By **B. T. P. BARKER, M.A., Director.**

For each of the three centres constituting the Department of Agriculture and Horticulture, viz., the Long Ashton and Campden Research Stations and the Berkeley Square Advisory Centre, the year 1935 will be remembered as associated with a definite event marking it as out of the ordinary.

In the case of the Campden Station the Ministry of Agriculture and Fisheries, the body responsible for its establishment and subsequent maintenance in respect of the government grant-in-aid, now no longer functions in the latter respect. On October 1st, 1935, that responsibility, as foreshadowed in last year's Report, was transferred to the Food Investigation Board of the Department of Scientific and Industrial Research. In actual practice this change will affect the Station but slightly in the immediate future, for financial arrangements will continue to stand for the present on much the same basis as since 1930. Later the canning industry may be called upon to contribute a larger share towards the cost of maintenance. By general desire of the Government Departments concerned and the canning industry the University of Bristol will continue to undertake the administration of the work of the Station as before. There will be, accordingly, no change in its position as one of the three centres of the Department of Agriculture and Horticulture under the control of the Agricultural Committee of the University. The only change, in fact, on the University side is the introduction of representatives of the Department of Scientific and Industrial Research on the Agricultural Committee and the Campden Management Sub-Committee. Mr. F. Hirst, M.Sc., remains in charge of the Station under a change of title from Resident Director to Director.

The outstanding feature of the year at the Berkeley Square Advisory Centre has been a remarkable increase in the number of enquiries for advice and assistance on problems of an agricultural character in the Bristol Province. The article on the Advisory Work of the Department, which will be found in another part of this Report, shows an increase in the total number of enquiries under the Advisory Scheme from 4,813 in 1934 to 6,545 in 1935. It will be noted in that article that practically the whole of this increase

has occurred in the sections of work dealt with by the Berkeley Square Centre. Moreover, the figures quoted do not include the very large amount of new work which has fallen upon the Centre through the establishment of the Poultry Pathology Laboratory there in 1932. This recent development has already fully justified itself; there can be no doubt that it has been the means of bringing many farmers to make use of the Centre for their other farming problems as well as those associated with poultry. In particular, the addition of the Poultry Pathologist to the staff has made it possible to extend the activities in Veterinary work as a whole: in this direction it is evident that there is great scope for further expansion.

For the Research Station at Long Ashton the event of the year was one of financial misfortune, all the more serious in its effects, direct and indirect, through its occurrence at the end of the series of difficult financial years resulting from the financial crisis which faced this country in 1931. Reference is made to the severe frost on the night of May 16th, when a temperature as low as 15°F. was recorded. Before that night the promise of abundant crops of fruit of all kinds was exceptional. The next day it was obvious that only a small fraction had escaped destruction. The crippling effect of this heavy loss of income has been of a most serious character. It is not that the general work of the Station has had to be materially curtailed: fortunately it has been possible to maintain this without drastic restriction. But in many directions expenditure in connection with very necessary natural developments of the work had been already deferred overlong during the preceding years of financial stringency: and this sudden, unexpected and heavy loss of income has now caused further unavoidable delay in proceeding with extensions of the work urgently needing attention. On certain members of the staff a further period of overstrain must fall owing to inability to provide adequate assistant staff, while expenditure on much-needed additional buildings and equipment must be still further deferred.

THE BERKELEY SQUARE ADVISORY CENTRE.

Staff.

Few changes in the staff at this centre have been recorded for 1935.

Mr. D. F. Ruston, B.Sc., N.D.A., Student Assistant to Dr. Dawe, the Advisory Officer in Agricultural Economics, resigned his appointment on being offered a post with the Empire Cotton Experimental Station, at Barburton, Transvaal. He has been succeeded by Mr. P. L. J. Trist, M.R.A.C.

Mr. C. W. Harwood, B.A., was appointed to undertake a special market gardening and fruit survey in the Pershore-Evesham area, now being carried out by the Economics Section on behalf of the Lord Astor Group which is enquiring into the question of land settlement for the unemployed. After a period of service of three months he resigned to take up an appointment with the National Smelting Company, Avonmouth. He has been replaced by Mr. L. A. C. Cook, B.A.

General.

During the year new laboratories at the Centre, required through the extension of the work of the Dairy Bacteriologist, have been provided.

The special grant of £400 made by the Milk Marketing Board through the Ministry of Agriculture and Fisheries for Costings work in connection with Milk Production, which was reported in the 1934 Report, is being continued for another year for extension of the work referred to.

The economic survey of willow growing carried out in Gloucestershire and Worcestershire under a special grant from the Ministry of Agriculture has been completed and a report of the survey has been published.

At a meeting of the Society of Chemical Industry held in Bristol in December, 1935, a paper on "Grass Silage and Silos" was contributed by Mr. A. W. Ling, the Agricultural Officer.

The Pig Husbandry Investigation carried out by the Agricultural Officer in conjunction with Mr. W. T. Price, the Agricultural Organiser for Wiltshire, on behalf of the Bath and West Society has been completed. The survey was extended over the counties of Gloucester, Somerset, Wiltshire, Dorset, Devon, Hampshire and Cornwall. A report of the survey has been prepared for publication in the Journal of the Bath and West Society, Vol. X, Sixth Series, 1935-36.

The broadcast talks for farmers arranged by the Bristol Provincial Advisory Conference on behalf of the B.B.C. and organised by Mr. A. W. Ling, have been continued throughout the year. These talks, under the general title "For Western Farmers in Particular," have brought many letters of appreciation and have served a very valuable purpose in establishing contacts with farmers throughout the Bristol Province, and indeed over a much wider area.

THE LONG ASHTON RESEARCH STATION.

Staff.

Miss M. L. Adams, who has had charge of the work on Domestic Fruit and Vegetable Preservation at the Station since its transfer to Long Ashton in 1931, has been appointed to an Inspectorship under the Board of Education. On the termination of her period of service at Long Ashton, Miss J. Ferguson, M.Sc., was appointed as her successor. During the courses on Fruit and Vegetable Preservation given by Miss Adams in July and August, 1935, Miss Ferguson acted for part of the period as her assistant and thus had that preliminary opportunity of getting into touch with that side of the work of the Section.

After seven years' service at the Station, firstly in connection with the investigations on fruit quality conducted on behalf of the Empire Marketing Board and latterly on a special investigation on sulphur dioxide in relation to the preservation of fruit pulp, Mr. J. C. Hinton, Ph.D., has resigned his appointment to take up a post with the British Flour Millers Research Association at St. Albans, Herts. The work on the sulphur dioxide investigation in hand at the time at the Station has been continued by Mr. F. C. Lewis, M.Sc., who was already attached to the staff of the Fruit Products section.

The special investigations on fungicides and insecticides arranged in conjunction with Imperial Chemical Industries, Ltd., have been continued throughout the year. Mr. A. C. Evans, B.Sc., D.I.C., who was appointed for this work at the outset, left the Station in May, 1935, on being offered an entomological post at Rothamsted. Until the end of the year temporary arrangements were made for a continuance of the work with the aid of the services of a member of the staff of Imperial Chemical Industries, Ltd. A new appointment is being made at the beginning of 1936. To assist on the entomological and mycological sides of these investigations Messrs. C. H. Hardy, B.Sc., and R. G. Munson, B.Sc., have been secured as temporary Student Assistants. The members of the plant pathology staff of this Station are closely associated also with these investigations.

Mr. J. E. Young, who has been Plantations Foreman at the Station since 1927, resigned on being given the appointment of Warden under the Land Settlements Association of the Lawford Estate, Ardleigh, Essex. Since about the same period Mr. C. R. Thompson, also a member of the pomological staff, was appointed

as Assistant Advisory Officer in Commercial Fruit Growing to the Kent Education Committee, the opportunity of reorganising the staff of that section and bringing it more into line with present-day needs has been taken. Mr. W. E. Berry, Ph.D., has been appointed to assist more particularly in the research work of this section and Mr. J. F. Oatway, for many years attached to the plantations staff, has been given the post of Plantations Foreman.

The rapid increase in the work of the Fruit Products section has made it necessary to provide an increase of staff in that section. As a temporary arrangement Mr. N. P. Bridgewater, B.Sc., is acting as an assistant to Mr. V. L. S. Charley, who has charge of this section, and the services of Mr. R. C. Curtis, a student of Bristol University, have been available also.

Buildings and Land.

Although there is pressing need for the addition of certain permanent buildings, referred to in the 1933 Annual Report, the financial position of the Station has caused their erection to be deferred for the present.

The necessity for the provision of a suitable house for the Plantations Officer, Dr. Swarbrick, has resulted in the purchase of a house situated on land adjacent to Fenswood Farm. This is the only addition to the Station property which has been made during the year.

Certain minor changes to the boundary of the land on the western side of the plantations have been necessitated by the widening of Wild Country Lane by the Somerset County Council. The area of land surrendered is only slight; but it involves the removal of an extensive glass house, which it is proposed to re-erect in the pot culture enclosure.

The chief development so far as the fruit plantations are concerned has been the establishment of the plot for trials of various systems of culture of cider fruit. Reference was made in last year's report to the acquisition of land for this purpose. The necessary cultivations have been carried out and the trees for the trials planted.

The land available for the new hillside cider orchard has now been fully planted with trees of selected cider varieties.

General.

The Annual Field Day of the Station was held on Thursday, May 1st. In addition to the sampling of the ciders made in con-

nection with the Cider Competitions and the experimental programme in the cider house for the year, and the experiments in progress in the fruit plantation, the features of the day included demonstrations by members of the staff relating to (a) methods of raising standard trees for farm orchards, (b) methods of planting and staking standard trees, and (c) improved methods of spraying and the simplification of spraying programmes for fruit and hops. Demonstrations were also given of methods of clearing ground of tree stumps with the aid of explosives. An exhibit relating to the various National Mark Schemes for the marketing of agricultural and horticultural produce was staged in the cider house and aroused great interest.

Fine weather again favoured the occasion and the usual numerous attendance of cider makers, fruit growers, market gardeners, farmers and others interested in the work of the Station resulted. The prizes in the Cider Competitions were distributed by Stanley H. Badock, Esq., J.P., LL.D., Pro-Chancellor, Treasurer and Chairman of Council of the University of Bristol, who also delivered a short address. The Chair was taken by Dr. T. Loveday, Vice-Chancellor of the University.

The following list includes the various organised parties which visited the Station on other occasions during the course of the year :—

The Gloucestershire Agricultural Valuers' Association.
 The Bristol and Gloucestershire Branch of the Sanitary Inspectors' Association.
 Bristol Grammar School Scientific Society.
 Colston's Boys' School.
 Clifton College Scientific Society.
 Bristol Post Office Retired Officers' Association.
 Bristol Branch of the Workers' Educational Association.
 French Agriculturists.
 Gloucester Teachers' Gardening Class.
 Fishponds Diocesan Training College Students.
 Eastern Counties Provincial Conference—Horticultural Section.
 Danish Scientists.
 East Bristol Unionist Association.
 Southville Ward of the Women's Unionist Association.
 Bristol Advisory Council of the Leagues of Youth.
 Brislington Women's Labour Party.
 Devonshire Teachers.
 Agricultural Education Association.
 Students attending Courses on Domestic Fruit and Vegetable Preservation at Cirencester.
 Bristol Central West Ward of the Women's Unionist Association.
 Fishponds Mothers' Meeting.
 Oxford Botany Department Senior Students.
 Wiltshire Agricultural Dairy Students.
 Bristol Federation of the League of Industry.
 Ministry of Agriculture Fruit Quality Control Officers.

Of particular interest may be mentioned the visits of parties from France and Denmark, the Horticultural Section of the Eastern Counties Provincial Advisory Conference, the members of the Agricultural Education Association, and the Quality Control Officers of the Ministry of Agriculture associated with various National Mark Schemes.

The number of individual visitors to the Station continues to increase annually and has included during the past year many scientists and horticulturists from all parts of the world.

Efforts were again made to restrict as far as possible the Show activities of the Station during the year, in view of the necessity of limiting expenditure and of economising the time of the staff. In this connection the arrangement now in force for the Bath and West Show, under which the Agricultural Education and Research Exhibit is co-ordinated by the Ministry of Agriculture and contributed to by the various agricultural educational bodies for the area in which the Show is held each year, is proving helpful. The accompanying list indicates the respective shows and exhibitions to which exhibits were sent during the year.

Devon County Show, Barnstaple.
 Bath and West, Taunton.
 Evesham Growers' Asparagus Show, Evesham.
 Three Counties Show, Gloucester.
 Cheltenham Spa Floral Fete, Cheltenham.
 Gillingham and Shaftesbury Show, Shaftesbury, Dorset.
 Melplash and District Show, Bridport, Dorset.
 International Soil Congress, Oxford.
 Imperial Fruit Show, Cardiff.
 Gloucester Root, Fruit and Grain Show, Gloucester.

The extent to which the experimental and investigational work on fruit farms and at other centres in various parts of the country has grown calls for special reference. The demands of this extra-mural work on the time of the staff are heavy and, in some cases, a large part of the time of individual members of the staff at certain periods of the year has to be spent away from Long Ashton. The work concerned is of a kind which cannot be carried out at Long Ashton itself or is required to supplement that in progress at the Station. The development of this side of the Station's activities is thus regarded as essential. Much of it involves a considerable degree of supervision and attention on the part of the growers on whose farms the experiments are being conducted. It is desired to tender to them the thanks of the Station for their cordial co-operation.

During the year, in addition to the regular members of the staff, the Station has had the advantage of the services of a number of

post-graduate research workers. These include Miss M. Carleton, M.Sc., and Mr. E. G. Goscombe, B.Sc., both of whom have been engaged upon entomological research ; Mr. D. L. G. Davies, B.Sc., who has been carrying out mycological investigations ; Mr. V. G. Vaidya, B.Ag., who has been working on Agricultural Chemistry ; and Mr. Sham Singh, B.Sc. (Agric.), and Mr. Donald Blair, B.S.A., who have both been engaged upon pomological problems.

During the year, also, a number of research workers and horticulturists have spent periods of various lengths at the Station studying the work in progress, including students from Australia, Canada, South Africa, Iraq, Denmark and Sweden.

During the course of November the Station was visited by the Plants and Soils Sub-Committee of the Agricultural Research Council. The work of the Station was closely inspected and, as a result, memoranda relating to the development of certain sections of the Station's work have been submitted to the Agricultural Research Council at its request.

PLUM ROOTSTOCK VARIETY TRIAL AT LONG ASHTON, 1925-1934.

PROGRESS REPORT.

By THOMAS SWARBRICK.

INTRODUCTION.

Plum varieties, with certain exceptions, are propagated by budding or grafting upon selected rootstocks. The rootstocks in common use are of two types (*a*) mixed seedlings, usually derived from one variety of plum such as Myrobolan or Common Mussel, and (*b*) clonal or vegetatively raised rootstocks such as Yellow Egg, Warwickshire Drooper and Common Plum. For many years the most commonly used rootstocks in commercial nurseries have been the collections of seedlings largely imported into this country from Europe. Of these, the sorts most often used are those known as "St. Julien," "Myrobolan" and "Mussel." Each commercial nursery has its own particular preference in the matter of plum rootstocks, based largely upon local experience of the growth of young trees in the nursery beds.

During the last fifteen years attention has been given to the development of pure lines of the above stocks. Selected seedlings of each group have been propagated by vegetative methods and the "type" thereby standardized. This work of selection and standardisation has been largely carried out at the East Malling Research Station.

It is well known that certain local English plum varieties, viz., Yellow Egg, Warwickshire Drooper, Kentish Bush and Blaisdon Red are produced not by propagation in the usual manner, but by suckers thrown up from the roots of the parent trees. In the localities where the above varieties are grown commercially there is invariably a relatively large supply of these "natural clones" and they are in consequence used extensively as rootstocks in their own localities, but only in small quantities by the large scale nurseries.

In 1925, a plum plot was planted at Long Ashton with trees raised at East Malling, mainly with the object of studying the

effect of rootstock on the incidence of certain pathological conditions peculiar to plum trees and partly to obtain reliable data regarding the growth and cropping of a number of commercial plum varieties when grown on certain selected rootstocks under Long Ashton conditions. The latter part of the investigation has proved the more interesting to date and the present progress report places on record the results obtained and the tentative conclusions reached regarding the effect of rootstock upon the growth and cropping of the scion variety during the first eight years after planting. During this period marked differences have been observed in the size, vigour and general appearance of the trees on the various rootstocks. The data on crop yield are not so complete as those on growth, since the crop was destroyed by the late spring frosts in 1931 and 1935. Silver Leaf disease has occurred in a number of trees and observations upon this aspect of the problem are also presented.

EXPERIMENTAL.

Material and Methods.

The plot comprises trees of the six varieties, Victoria, Ponds Seedling, Purple Pershore, Pershore Yellow Egg, Monarch and Blaisdon Red. Trees of each variety are growing on each of the seven rootstocks, Blaisdon Red, Brussels, Common Mussel, Common Plum, Myrobolan B. Yellow Egg and St. Julien, with two exceptions, viz., there are no trees of Purple Pershore on Blaisdon Red and only one tree of Ponds Seedling on Common Plum. The rootstocks were from clonal material and the trees raised and supplied by East Malling Research Station for the purposes of the trial.

With the exception of Ponds Seedling on Blaisdon Red which was not planted until two years after the remainder of the plot, all trees were planted as one-year-olds in November, 1925. Detailed records of height, weight, girth, etc., of each tree were taken at the time of planting. Since the present contribution is a progress report no reference is made to these detailed records. All trees have been kept under constant and careful observation, and individual tree records of height, spread, girth, crop yield and general appearance have been taken annually.

The appearance of Silver Leaf disease on the plot provided an opportunity for a study of this phase of the problem, each tree being carefully examined during the late summer for any signs of the disease.

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or

Results.

The data are presented in four Tables. Table I sets out the average girth, height and spread of the trees of each variety on each rootstock. This table also includes a note upon the general appearance of the trees and a "composite" figure for the total growth. This composite growth figure is explained in detail later.

Owing to spring frosts in 1931 and 1935 only three crops have been obtained up to the end of 1935. Table II gives the average yield per tree for each variety on each rootstock for each season of cropping, together with the totals of these averages for the three crops in each case. These latter figures only are discussed in the present report.

Table III contains the data for relative tree size and crop yield for the various stock and scion combinations. The figure for tree size is obtained by assigning to each group of trees on a given rootstock for each variety, a figure denoting the relative order of the groups on the various rootstocks in the matter of girth, height and spread respectively. The sums of these figures for each variety on each rootstock are then arranged in descending order thus giving a measure of relative "total growth." For example, in Table I it is shown that for the scion variety Blaisdon Red the trees on Myrobolan B are the largest in girth, height and spread, and since there are seven rootstocks they receive a figure 7 for each of these measures, giving a total growth figure of 21. The trees of this variety on Common Plum, on the other hand, are the smallest in girth, height and spread, and hence receive a total growth figure of only 3. The order of total tree size is thus 7 (largest) and 1 (smallest) respectively. It should be pointed out, however, that the measurements of height and spread should be used with caution, since both are liable to be affected by such factors as crop and wind. The girth measurement, however, is not liable to fluctuate to the same extent. The relative order of crop yield is obtained from the data given in Table II. From the data presented in Table III it is possible to compare tree size and crop yield directly.

Table IV sets out the data and observations upon the incidence of Silver Leaf. A number of trees have died during the period covered by this report but, although Silver Leaf has been very prevalent, there have been no deaths from this cause.

DISCUSSION.

I. The Effect of Rootstock upon Tree Growth, Vigour and Condition.

Blaisdon Red. Blaisdon Red like Yellow Egg is present on the plot both as a rootstock and a scion variety. A total of 60 trees were planted on this rootstock, including 12 trees of the variety on its own roots. Considering rootstock effect alone it is shown in Table I that the rootstocks Myrobolan B and Common Mussel have produced appreciably larger trees with Blaisdon Red as scion variety than Blaisdon on its own roots, the relative growth figures being 21, 18, and 13 respectively. The Blaisdon trees on Yellow Egg are of approximately the same size as those of Blaisdon on its own roots, the growth figures being 14 and 13 respectively. Blaisdon Red has proved the best of all the rootstocks used in this trial for the variety Monarch, the total growth figure being 21, which means that these trees were the largest in girth, height, spread. It also proved a moderately good stock for Ponds Seedling, the total growth figure for these trees being 13, against totals of 20 and 19 for trees on Myrobolan B and St. Julien respectively. This figure indicates that Blaisdon is likely to be a good rootstock for Ponds Seedling since, as was pointed out earlier, these trees are three years younger than the other varieties on the same stock. There are unfortunately no trees of Purple Pershore on this rootstock. Victoria has also grown well on this stock, the trees having a total growth figure of 19, as compared with 22 and 20 for trees on Brompton and Myrobolan B respectively. Yellow Egg has made moderately good trees, the total growth figure being 15, against 20 and 17 for trees on Myrobolan B and Yellow Egg respectively. In general, therefore, it appears that all the five scion varieties worked on Blaisdon have grown moderately well, but that those of Monarch are particularly good.

A noticeable feature in connection with this variety when used as a rootstock is the number of trees that have died (9.6% of the total number planted). This figure is given in Table IV as a separate percentage for each scion variety, and it is there shown that out of 12 trees, 8.5, 16.6, 8.5 and 25% have died of the varieties Monarch, Ponds Seedling, Victoria and Yellow Egg respectively. The large number of deaths of Yellow Egg is outstanding and strongly suggests incompatibility, although the remaining trees have grown moderately well.

It has been repeatedly observed that the trees worked on to Blaisdon Red show marked yellowing of the foliage throughout

the season. In some cases the yellowing appears as a distinct marginal effect.

Brussels. A total of 66 trees was planted on this stock, 12 of each of the varieties except Blaisdon, of which there were only 6 trees.

The outstanding feature of this stock is the poor growth made by all varieties except Pond's Seedling. The trees of Blaisdon on Brussels have a total growth figure of 8 as against 21 on Myrobolan B, but the trees are much better than those on Common Plum which have a total growth figure of only 3. The poorest trees of the varieties Monarch, Purple Pershore and Victoria are associated with this stock, these trees having a total growth figure of only 3 as compared with 21 for Monarch on Blaisdon Red, 18 for Purple Pershore on Myrobolan B, and 20 for Victoria on Myrobolan B. Ponds Seedling has made fair growth on Brussels, having a total growth figure of 12 by comparison with 20, 19 and 13 for trees of this variety on Myrobolan B, St. Julien and Blaisdon. The trees of Yellow Egg are also very poor on this stock with a total growth figure of 6 as compared with a figure of 3 for the poorest trees of the variety, which are on Common Plum, and 20 for the trees on Myrobolan B. It is clear that Brussels is an undesirable rootstock for all varieties except perhaps Ponds Seedling, but even this variety has grown much better on some of the other rootstocks.

9.0% of the total number of trees originally planted on this stock have died. This figure, however, is made up entirely of the deaths from the two varieties Blaisdon Red and Victoria of which 66.6% and 16.6% have died respectively.

In general the trees on this stock appear sparsely foliated and rather gaunt with a pronounced tendency to poor root hold.

Common Mussel. A total of 79 trees was planted on this rootstock. This number was made up as follows: Victoria 12, Yellow Egg 16, Purple Pershore 15, Ponds Seedling 4, Monarch 14 and Blaisdon Red 18. These different numbers are due to the difficulty of obtaining a satisfactory run of nursery material.

It is evident from Table I that, in general, the trees on this stock have grown fairly well, a notable exception being the variety Pond's Seedling the trees of which are very poor on Common Mussel. These latter trees are in fact very little better than those on Yellow Egg which have a total growth figure of 4, those on Common Mussel having the value 5. Blaisdon Red has made good trees, the total growth figure being 18, which compares with 21 for the trees on

Myrobolan B, and 3 for those on Common Plum. Monarch has a growth figure of 13, which compares with 21 for Monarch on Blaisdon and 4 for Monarch on Brussels. Purple Pershore has also grown fairly well on Common Mussel, having a growth figure of 13, which compares with 18 for trees on Myrobolan B. Victoria has grown moderately on this stock by comparison with the trees on Brompton, Myrobolan B, and Blaisdon. Yellow Egg with a growth figure of 14 has grown fairly well, since this figure compares with 3 for the trees on Common Plum, and 20 for those on Myrobolan B.

The number of trees which have died on this rootstock is small, being only 2.5% of the original plant of 89 trees. These deaths consist of one tree each of the varieties Blaisdon Red and Victoria.

It has been observed that the foliage of all varieties on this stock tends to be pale in colour by comparison with that on such stocks as Myrobolan B. In some varieties, notably Blaisdon, the foliage becomes distinctly yellow comparatively early in the autumn.

Common Plum. Only 48 trees in all were planted on this rootstock, including a single tree of Ponds Seedling, and only five trees of each of the varieties Blaisdon Red and Monarch.

The growth data given in Table I show that without exception this stock is associated with small and poorly developed trees. Blaisdon Red and Yellow Egg in particular have both made very poor trees, the growth figure being 3 in each case against a figure of 21 and 20 respectively for those varieties on Myrobolan B. Monarch on Common Plum has a growth figure of 6 by comparison with 18 for the trees of this variety on Myrobolan B. There is only one tree of Ponds Seedling on this stock so that comparisons are not possible. This tree, however, has grown fairly well, having a growth figure of 11. Purple Pershore and Victoria on Common Plum also have growth figures of 6 and 7 respectively, which by comparison with figures of 18 and 20 for trees on Myrobolan B, indicate poor trees. It is clear therefore that this stock is definitely associated with small trees.

Notwithstanding the very poor growth made by the trees on Common Plum, the number of deaths is not so high as might be expected. Of the total trees planted the death rate is 4.2% due entirely to two trees on Blaisdon. Actually this represents a loss of one-third of the total trees of this variety and indicates a marked incompatibility between these two varieties.

The general condition of all trees on this stock is markedly poor. In almost every case the field notes indicate poor thinly foliated trees with much yellowing of the foliage and poor root hold. The trees generally lack vigour and vitality.

Myrobolan B. The large total of 115 trees was planted on this rootstock, viz., 24 trees each of Victoria and Blaisdon Red, 18 of Yellow Egg, 21 of Purple Pershore, 16 of Monarch and 12 of Ponds Seedling.

The growth data given in Table I show clearly that Myrobolan B is invariably associated with large if not the largest trees of all varieties. In fact the largest trees of Blaisdon Red, Ponds Seedling and Purple Pershore occur on this rootstock, and also the second largest of the varieties Monarch, Yellow Egg and Victoria. Actually the largest trees of Victoria are on Brompton, but this has not been included as a stock for any other variety. Excluding these trees, therefore, the largest trees of Victoria are associated with Myrobolan B. There can be no doubt of the outstanding vigour of the trees on this stock.

The death rate for trees on Myrobolan B is the lowest of all the rootstocks used in the trial, being only 1.7% in a total of 115 trees. This figure arises from the death of one tree each of the varieties Victoria and Yellow Egg. The latter died of Bacterial Canker in 1932.

The condition of all the trees on this rootstock is good. Growth is vigorous and the leaves are invariably large and of good colour. The root hold is also invariably good.

Yellow Egg. This variety, like Blaisdon Red, is used both as a scion variety and as a rootstock. A total of 89 trees was planted, including 21 trees of Yellow Egg on its own roots.

The growth data given in Table I show that Yellow Egg is associated with trees of variable size depending entirely upon scion variety. The trees of Blaisdon Red on Yellow Egg are the third largest of this variety, having a growth figure of 14 by comparison with 21 and 18 for the trees on Myrobolan B and Common Mussel respectively. The trees of Monarch on Yellow Egg are very poor, having a growth figure of only 9 as against 21 and 18 for trees on Blaisdon and Myrobolan B. Yellow Egg has given the smallest trees of Ponds Seedling of all the rootstocks used in this trial. Purple Pershore has a growth figure of 12 as against 18 and 13 for trees on Myrobolan B and Common Mussel. The trees of Victoria on this stock have a growth figure of only 8 and are the third smallest trees, comparing with a growth figure 20 for trees on Myrobolan B. The trees of Yellow Egg on their own roots have a growth figure of 17 and are only exceeded in size by those on Myrobolan B. In no case, therefore, is this stock associated with the largest trees of any variety but is definitely associated with the

smallest trees on Ponds Seedling and the smaller trees of Victoria and Monarch.

The death rate for trees on this stock is relatively low, being 4.4% for a total of 89 trees. This is made up of one tree each of Victoria and Purple Pershore, and three trees of Blaisdon Red. It is clear, therefore, that Blaisdon Red and Yellow Egg are somewhat incompatible, since the combination of Yellow Egg on Blaisdon Red also showed a high death rate (25%).

The general condition of the trees on Yellow Egg is good with the exception of Monarch and Ponds Seedling, which are very poor. It is noticeable that many of the trees, particularly the varieties Purple Pershore, Monarch and Ponds Seedling, have very poor roothold.

St. Julien. A total of 83 trees was planted on this rootstock, including 20 trees of Victoria and 17 of Yellow Egg.

The growth data given in Table I show that Blaisdon Red has done badly on this stock, the growth figure being 7, which is the second smallest. Monarch and Ponds Seedling on the other hand have grown moderately well on St. Julien, the growth figure being 14 and 19 respectively. Purple Pershore shows a growth figure of 11 as compared with 18, 13 and 12 for trees on Myrobolan, Common Mussel and Yellow Egg. Victoria on this rootstock is of medium size, being the fourth largest with a growth figure of 16 by comparison with a figure of 20 for the trees Myrobolan B. Yellow Egg has made very poor trees on St. Julien, the growth figure being only 9. It is evident from the above data that the only trees that have grown reasonably well on St. Julien are Ponds Seedling, Victoria and Monarch. It is not a good stock for Yellow Egg or Blaisdon.

St. Julien rootstock shows the phenomenally high death rate of 21.4% in a total of 89 trees. Of the trees originally planted 20% of the Blaisdon, 66% of the Monarch, 25% of the Purple Pershore and 23% of Yellow Egg trees have died. Only Ponds Seedling and Victoria show no deaths. It is clear, therefore, that an important and outstanding feature of this rootstock is the large number of trees of certain varieties which die during the early years after planting. The data upon growth set out in the previous paragraph have been obtained from the trees that have so far survived, and must be considered in the light of the data mentioned above.

The notes on tree condition show that the surviving trees are fairly good, though the foliage shows a slight tendency to premature

autumn yellowing. The Purple Pershore trees show a poor root hold.

Brompton. Only seven trees, all of them Victoria, were planted on this stock. They have made excellent growth, the trees being the largest and best of this variety, having a growth figure of 22. The condition of the trees is excellent. One tree has died, in 1934.

II. The Effect of Rootstock upon Crop Yields.

The trees in this trial have blossomed more or less freely since 1931 but, owing to late spring frosts in 1931 and 1935, only three crops have materialised during the period covered by the present report. The crop yield data must, therefore, be interpreted with caution. The average yield per tree for each year's crop and the total of these averages to the end of 1935 are set out in Table II. The relative order of these totals is set out in Table III.

Blaisdon Red. It is shown in Tables II and III that this rootstock is associated with the highest mean yield per tree in the three scion varieties, Monarch, Ponds Seedling and Victoria. The superior performance of these trees is outstanding, particularly in the case of Ponds Seedling and Victoria, where the yield is 11 kilos and 7 kilos respectively above the next highest. Unfortunately there are no trees of Purple Pershore on this rootstock. Of the other two varieties, Yellow Egg has yielded badly on this stock, the trees being third lowest in mean yield per tree. The unworked trees of Blaisdon have not yielded so well as those worked on to some other rootstocks. In fact the yield of the unworked trees is only 31 kilos per tree, whereas those on Myrobolan B, Yellow Egg, and Common Mussel have yielded an average of 50, 46 and 42 kilos per tree respectively.

Brussels. Reference to the data shows that out of the six varieties used in this trial, Brussels is associated with the lowest mean yield per tree in the four varieties Monarch, Purple Pershore, Victoria and Yellow Egg, and the second lowest mean yield for the variety Blaisdon Red. For the four varieties, Monarch, Purple Pershore, Victoria and Yellow Egg, the yields on this rootstock are less than one third of those on the best stocks, and for Blaisdon Red less than a half. The variety Ponds Seedling provides notable contrast to the low yields on Brussels, being second only to the yield of the trees on Blaisdon Red, with a yield of 13 kilos per tree, as against 24 kilos for the trees on Blaisdon. It is clear therefore that, with the possible exception of Ponds Seedling, Brussels is a most undesirable rootstock for the scion varieties used in this trial.

Common Mussel. In Tables II and III it is shown that Common Mussel is associated with the second highest yielding trees for the 2 varieties, Monarch and Yellow Egg. The actual mean yields per tree are 8 and 37 kilos in the case of Monarch and Yellow Egg, as against the highest mean yields for these two varieties of 11 and 44 kilos respectively. It is associated with the third highest yielding trees of Blaisdon Red, the yield of these trees being 42 kilos, which is 11 kilos per tree more than the yield of Blaisdon Red on its own roots. Victoria has cropped only moderately well on Common Mussel, the yield being the fifth highest. Ponds Seedling has failed almost completely on this rootstock, the mean yield per tree being only 2 kilos, as against 24 and 13 kilos for the trees on Blaisdon Red and Brussels respectively. With the exception of Ponds Seedling, and possibly Victoria, the trees on Common Mussel have cropped well by comparison with those on the other rootstocks used.

Common Plum. Reference to the tables shows at once that without exception the trees on Common Plum have produced very low average yields. Blaisdon Red on Common Plum has given the lowest yield for this variety, whereas the trees of Monarch, Ponds Seedling, Purple Pershore and Yellow Egg on this rootstock are the second lowest yielding, and Victoria the third lowest. Clearly this rootstock is most undesirable in so far as cropping is concerned.

Myrobolan B. The data given in Tables II and III show that this rootstock is associated with the highest yielding trees of the varieties Blaisdon Red and Purple Pershore. The trees of the latter variety are outstanding with the very high total yield per tree of 69 kilos, which is 9 kilos higher than the next highest yield for this variety which occurs in the trees on Yellow Egg. Both Monarch and Yellow Egg have yielded well on this stock, the crops being the third highest for each variety. The two varieties Ponds Seedling and Victoria, however, have produced significantly low yields on Myrobolan B, being the third and second lowest yielding trees respectively. The low yields of the trees of these two varieties are notable, because in both cases the trees are the largest of any on the plot. The very low mean yield of the Victoria trees may be due to the high incidence of Silver Leaf in these trees. In general, therefore, it appears that, with the exception of Victoria and Ponds Seedling, Myrobolan B is associated with the high yielding trees.

Yellow Egg. The results given in Tables II and III show that almost without exception the rootstock Yellow Egg is associated with the higher yielding trees. The unworked trees on Yellow Egg have cropped more heavily than when worked on to any other

rootstock used in this trial. The yield of these trees is 44 kilos as compared with the next highest yield of 37 kilos for the trees worked on Common Mussel. Blaisdon Red and Purple Pershore on this rootstock are the second highest yielding trees of these two varieties, with yields of 42 and 60 kilos respectively, as against the highest yielding trees with 50 and 69 kilos respectively. Yellow Egg as a rootstock is associated with the third highest yielding trees in the variety Ponds Seedling, and the fourth highest in the varieties Monarch and Victoria. It is clear that this rootstock is associated with high yielding trees, and while the relation between tree size and cropping will be discussed in a later section, attention must be called at this point to the fact that although the trees on Yellow Egg have cropped heavily, they are by no means always large trees. In fact, those of Ponds Seedling are the smallest trees of this variety on the plot.

St. Julien. Reference to Table II shows that with one notable exception—that of Victoria—this rootstock is associated with the lower yielding trees. Thus the trees of Blaisdon and Monarch with yields of 22 and 4 kilos respectively are the third lowest, and those of Ponds Seedling, Purple Pershore, and Yellow Egg with 5, 51 and 21 kilos respectively, the fourth lowest yielding trees of these varieties. Victoria is the outstandingly high yielding variety on this rootstock, since the trees have yielded 53 kilos per tree which makes them second only to those on Blaisdon with an average of 60 kilos per tree. It is clear, therefore, that except for Victoria the trees on St. Julien have not cropped heavily in comparison to the others.

Brompton. Only one variety, Victoria, is worked on this rootstock and the trees are third in order of cropping for the variety, the yield being 52 kilos per tree as against 60 kilos for the trees on Blaisdon Red.

III. Relation between Tree Size and Cropping.

In the two preceding sections the effect of rootstock upon tree size and cropping has been discussed, but no attempt was there made to relate these two aspects of rootstock effect. For purposes of comparison the data upon tree size and total yield have been collected together into Table III. The figures given for either tree size or crop yield are the order of descending relation. An examination of Table III shows that there are 42 rootstock and scion combinations on the plot. In 36 of these combinations there appears a marked positive correlation between tree size and crop yield, the large trees being associated with the high yields and small

trees with low yields. There are, however, six outstanding cases where the above general statement does not apply.

The first of these exceptions is the case of Monarch on St. Julien, where the trees have grown to be the third largest, but they fall to fifth in order of yield. The variety Ponds Seedling provides two outstanding cases of a differential rootstock effect upon growth and cropping. The trees of Ponds Seedling on Myrobolan B are the largest of this variety, yet in crop they fall to the fifth place. The actual yield of these trees is only 3 kilos per tree as against 24 kilos for the smaller trees on Blaisdon Red. The second case of Ponds Seedling concerns the trees on Yellow Egg, and is even more striking. These trees are the smallest of this variety yet their yield is third highest, the actual yield being 7 kilos per tree, which is of course, far below the yield of the trees on Blaisdon Red, but is approximately double the yield of the much larger trees on Myrobolan B. Ponds Seedling is, in fact, the most sensitive variety to rootstock influence used in this trial. Purple Pershore on Common Mussel also provides an example of a differential effect upon growth and cropping, since these trees have grown to be the second largest of this variety, yet in crop yield they occupy only fourth place. Victoria on Myrobolan B is also an outstanding case of very large trees with relatively very small yields. These trees are actually the second largest of this variety, yet they have the second lowest yield per tree. This large disparity between tree size and crop yield in the variety Victoria may be due in fact to the incidence of Silver Leaf disease, a point that will be discussed in the next section. The final case to which attention is called is that of Yellow Egg on Blaisdon Red, where the trees are relatively large yet their crop is relatively small. The above trees are the third largest in size but they are fifth in order of yield.

It is clear from the preceding paragraph that rootstock may affect both tree size and crop yield differentially, although growth and cropping are usually positively correlated. In particular cases, however, of which special mention has been made, these effects are not parallel, large trees being associated with small yields and *vice-versa*.

IV. Rootstocks in Relation to the Incidence of Silver Leaf Disease.

The data relating to the incidence of Silver Leaf are set out in Table IV. They are grouped under two headings, one giving the total number of trees showing Silver Leaf up to 1932, and the other the actual number of cases present at the end of 1934. Although

there has been a very high incidence of Silver Leaf, particularly in the variety Victoria, there have been no deaths from this disease.

The possible effect of rootstock upon the incidence of Silver Leaf in the variety Victoria is shown in the following table which gives the percentage incidence of Silver Leaf under field conditions in the trees worked upon the various rootstocks. The data are given up to the end of 1932, and again in 1934. This variety has been singled out because of its obvious susceptibility to this disease.

<i>Rootstock.</i>	<i>% Trees Affected.</i>	
	1932.	1934.
St. Julien	40.0	35.0
Myrobolan B	37.5	28.7
Yellow Egg	33.3	8.5
Common Mussel	16.6	16.6
Blaisdon Red	16.6	33.2
Common Plum	8.5	Nil.
Brussels	8.5	8.5

It is evident from the above table that by the end of 1932 infection was more or less severe in the trees on all the rootstocks, but was markedly less in those on Brussels and Common Plum. The rootstocks, Common Mussel and Blaisdon Red also appear to be associated with a low incidence of the disease. The rootstocks St. Julien, Myrobolan B and Yellow Egg, however, are clearly associated with a very high degree of incidence. The high incidence in the case of the trees on Yellow Egg is particularly interesting since there is a general impression amongst fruit growers in the Evesham-Pershore area that Yellow Egg is almost immune to Silver Leaf, and that it tends to give this immunity to the scions that are worked upon it.

Three varieties are outstanding as being particularly subject to Silver Leaf, viz., Victoria, Yellow Egg and Blaisdon Red. Victoria is undoubtedly the most susceptible variety, but the number of cases in both Yellow Egg and Blaisdon has been relatively high. The data presented in this paper clearly dispose of the idea that Yellow Egg is immune to Silver Leaf.

Attention should be called to the apparent recovery from Silver Leaf that has occurred during the period 1932 to 1934, but more particularly during the summer of 1934. During the latter part of that summer when the usual notes upon vigour, general appearance and the incidence of Silver Leaf were being made and compared with the notes made during 1933, it was found that trees which had previously been recorded as badly affected with Silver Leaf in 1933 were free from it in 1934. In order to be certain of these observations a second check was made, and there can be no doubt

about the observations. The reason for this apparent recovery during 1933-34 and its permanence or otherwise are not under discussion at this point. The observations are recorded here, however, because of their great interest and in order to complete the preliminary survey of the rootstock trials.

Brooks and Brenchley * have placed on record their observations upon the differential recovery to inoculations of Silver Leaf fungus spores shown by Victoria Plum trees on the two rootstocks Myrobolan B and Common Plum. Their data clearly indicate a much higher rate of recovery for the trees on Common Plum. They also advance data supplied by the workers at East Malling for naturally occurring attacks of Silver Leaf, which show a significantly greater proportion of recoveries in the trees on Common Plum than in the same varieties on Myrobolan B. There was, however, no significant difference in the incidence of infection under natural conditions.

It is evident that the trees at Long Ashton are exhibiting some apparent recovery from Silver Leaf, but it is too early to draw final conclusions.

In contrast to the observations of Brooks and Brenchley, just cited, the observations made at Long Ashton show clearly a difference in the naturally occurring infections of Silver Leaf which may be due to rootstock. During the period 1926 to 1932 there was only one case of Silver Leaf in a total of 50 trees on Common Plum, whereas there were 16 cases in a total of 115 trees on Myrobolan B and 12 cases in a total of 89 trees on Yellow Egg.

CONCLUSIONS AND SUMMARY.

1. The seven rootstocks—Blaisdon Red, Brussels, Common Mussel, Common Plum, Myrobolan B, Yellow Egg and St. Julien—as used in this trial have shown marked effects upon tree size, crop yield and the general appearance of the six scion varieties, Blaisdon Red, Monarch, Ponds Seedling, Purple Pershore, Victoria and Yellow Egg.

2. *Blaisdon Red* is associated with the more vigorous trees in all varieties except Purple Pershore of which there are no trees. The trees of Monarch, Ponds Seedling and Victoria have cropped most heavily on this stock. Yellow Egg, however, has not cropped well on Blaisdon. Almost 10% of the total trees on this stock have

* Journal of Pomology and Horticultural Science, Vol. 13, p. 135. 1935.

died, the varieties suffering most in this respect being Yellow Egg, Ponds Seedling, Victoria and Monarch. A yellowing of the foliage is generally associated with this stock. The incidence of Silver Leaf in trees on this stock is not high.

3. *Brussels*. This has proved a poor rootstock both as regards tree size and crop yield for all varieties except Ponds Seedling, which has grown moderately and cropped well on Brussels. Of the total trees planted 9% have died, these being entirely Victoria and Blaisdon Red. The trees are generally very poor and have a poor root hold. The incidence of Silver Leaf in the trees on this stock has been low.

4. *Common Mussel*. This has proved a moderately good stock both as regards tree size and crop yield for all varieties except Ponds Seedling. The trees of this latter variety have grown badly and cropped lightly. Only 2.5% of the total trees have died, the varieties being Blaisdon Red and Yellow Egg. The incidence of Silver Leaf is rather high.

5. *Common Plum*. This has proved without exception to be a poor rootstock. The trees are invariably small and crop yield light. The percentage of deaths is 4.2, being due entirely to a very heavy loss of Blaisdon Red. The trees lack vigour, are thin in foliage and have a poor root hold. The incidence of Silver Leaf in the trees on this stock is extremely low.

6. *Myrobolan B*. Without exception, this stock is associated with the larger and more vigorous growing trees. The largest trees of Blaisdon, Ponds Seedling, Purple Pershore, Victoria and Yellow Egg are all associated with Myrobolan B. The crop yield of all varieties is high except for Ponds Seedling and Victoria, where the crop is very low notwithstanding the large trees. The percentage of trees that have died on this stock is only 1.5%. The trees on this stock are generally strong and vigorous with an abundance of dark green foliage. The incidence of Silver Leaf is very high, occurring in all varieties except Purple Pershore.

7. *Yellow Egg*. The unworked trees of this rootstock are outstanding in that they are the second largest in size and highest in yield of all the trees of this variety. Blaisdon Red and Purple Pershore have also made good trees and cropped well on this stock, but Monarch, Victoria and particularly Ponds Seedling have made small trees which for their size have cropped heavily. Only 4% of the total trees on this stock have died, Blaisdon Red being the variety most affected. The trees generally are healthy in

appearance except those of Ponds Seedling, but they have a poor root hold. The incidence of Silver Leaf in the trees on this stock has been high.

8. *St. Julien*. Victoria and Ponds Seedling are the only two varieties that have grown and cropped satisfactorily on this stock. Blaisdon Red, Purple Pershore and Yellow Egg have all made poor trees that have cropped lightly. The stock is outstanding for the large number of trees that have died, 21% out of 89 trees planted. Monarch has suffered to the extent of 66%, and Purple Pershore, Yellow Egg and Blaisdon 25%, 23% and 20% respectively. The remaining trees are satisfactory in appearance with healthy foliage, but show a tendency to poor root hold.

9. In general, the large trees have produced the large crops but this must be qualified by the fact that there are outstanding cases where rootstocks have affected tree size and cropping differentially. Thus Monarch on *St. Julien*, Ponds Seedling on Myrobolan and Victoria on Myrobolan have all made large trees, but their yield is very low. The trees of Ponds Seedling on Yellow Egg on the other hand are very small but they have cropped heavily.

10. The incidence of Silver Leaf shows marked rootstock and varietal differences, the varieties most affected being Victoria, Yellow Egg and Blaisdon. One or more cases have occurred in all varieties. The rootstocks most frequently associated with Silver Leaf are Myrobolan B, *St. Julien* and Yellow Egg. Common Plum and Brussels have appeared to be associated with a low incidence of disease under Long Ashton conditions during the period covered by this trial.

11. There was a marked apparent recovery from Silver Leaf during the period 1933-34. This recovery was noted on all rootstocks except Brussels, but the data at present available do not allow of any conclusions regarding the effect of rootstock upon the recovery from this disease.

THE FROST OF MAY 1935.

By G. T. SPINKS and T. SWARBRICK.

The frost which occurred in May, 1935, was one of such exceptional severity for that season of the year, and the resulting loss of fruit crops was so serious, that a record of the incidence of frost damage in the plantations of the Long Ashton Research Station may be of interest.

The following account records the available meteorological data and the extent of the injury sustained by various kinds and varieties of fruit in different parts of the plantations.

Altitude and Aspect.

The plantations cover an area of about 120 acres. They are situated in the bottom and on the lower slopes of a valley running from east to west. The northern section of the plantations is separated from the main portion by a public road and a number of houses and farm buildings. To the north of the road the ground rises in a gradually increasing slope to a height of about 450 feet, the plantations extending up this slope to an altitude of about 250 feet.

The main portion of the plantations, in the bottom of the valley, occupies ground which is almost level from north to south, but slopes very gently towards the west: at the eastern end, however, the ground slopes more steeply east down to a brook. The mean altitude of this level area of the plantations is about 160 feet. A deep railway cutting runs from east to west through the centre of this portion.

Along the south side of the valley the ground rises, at first gently and then quite steeply, to a ridge about 250 feet in height. The upper and steeper parts of this slope are planted only with young standard apple trees which have not yet come into bearing.

Shelter.

Almost the whole of the plantations are very exposed to winds from the east and the west. Buildings at the west end may afford a little shelter to a small area; apart from this, the only shelter is provided by three windbreaks, of poplar, beech and myrobalan plum respectively, which cross the more level part of the main portion of the plantations from north to south.

Meteorological Data.

Data were obtained from the meteorological station situated in an open position near the centre of the plantations at an altitude of 160 feet.

The following temperatures were recorded at 9 a.m. on four days—

	Min. Screen (°F.)	Min. Grass. (°F.)
May 16	38	37
May 17	28	21
May 18	34	30
May 19	32	28

The wind, as recorded on an anemobiograph, backed from S. to N., being mainly N.E., during May 16th. The maximum velocity was 24 m.p.h., but by 11 p.m. this had fallen below 5 m.p.h. From midnight to 6 a.m. on May 17th the direction of the wind, if any, is recorded as N., but it was almost completely calm. After 6 a.m. there was increasing wind from between W. and N.E. and from 8 a.m. onwards there were gusts up to 24 m.p.h. from N. E.

No additional data are available for particular parts of the plantations.

Effect of the Frost.

Very serious damage was done by the frost throughout the plantations. There is no doubt that the low temperature of May 16th-17th was the direct cause of the failure of the crops, for immediately after the frost the tissues of the flowers and young fruits were seen to have been killed. There is thus no possibility that the failure was due to slow germination of pollen or lack of pollinating insects brought about by cold weather throughout the blossoming time.

The effect of the frost on the various kinds of fruits is given under separate headings below.

Apples.—A large proportion of the plantations is planted with apple trees in the form of bushes or standards. A number of dessert, culinary and cider varieties are grown and occupy ground ranging from the lowest to the highest altitudes on the farm. Most of the trees bore abundant blossom and at the time of the frost those varieties which are mid-season in flowering were in full bloom.

With a few notable exceptions, apples suffered very severely, the crop of almost all varieties in most parts of the plantations

being a total loss. There was 100% damage to Worcester, Bramley, Lane's, Cox, Allington, and many other varieties on the majority of the plots. On a plot occupying the highest point of the comparatively level central portion of the plantations, there were a few fruits of Worcester on the upper parts of the bush trees. As trees of Lane and Bramley on the same plot bore no crop this may indicate that these varieties are rather more susceptible than Worcester to frost damage.

On an adjoining plot where the general damage was 100%, trees of Early Victoria suffered only 90% injury. The uninjured flowers were in the centres of the trees and appear to have been protected by the abundant foliage produced as the result of suitable manuring. Edward VII on this plot carried a full crop. The latter variety, owing to its late-blooming habit, is evidently much less susceptible to frost damage than many varieties, for on another plot it was also quite uninjured, whereas interplanted Allingtons sustained 100% injury.

Standard trees of Bramley, Worcester, Newton and Blenheim, in a plantation on the southern slope escaped damage almost entirely. This may be due partly to the height of the trees, as the layer of cold air may not have extended as high as the heads of the trees. It is possible that the slope also provided drainage for the escape of the cold air. On an adjoining plot at the same altitude, however, all the blossom on bush trees of Cox and Worcester was killed, though it is worthy of note that the open flowers of Superb bushes on this plot were quite uninjured and the trees carried a full crop. Superb thus appears to be less susceptible than the other two varieties to frost, but the difference in susceptibility is not very great, for on another plot on the lowest part of the farm, where the temperature was probably lower, damage was equally severe on Superb and Worcester.

The most striking observation on the incidence of frost damage at this Station was made in a grass orchard of standard trees of cider varieties. This orchard is on almost level ground at the north-west corner of the main portion of the plantations and is partially surrounded by the Station buildings. The trees are thirty years old, with thick heads: they have now reached such a size that, in most parts of the orchard, the heads of neighbouring trees are touching. The majority of the trees were in full bloom, or at the pink bud stage, at the time of the frost, yet the amount of damage was negligible on all varieties in the orchard. This is a surprising result, as the situation of this orchard, with no apparent air drainage, would

have led one to expect severe damage. The only explanations of this which have yet been suggested are firstly, that the thick heads of the trees may have kept up the temperature in the orchard by checking radiation from the ground, by preventing the escape of the warmer air which was present before the temperature fell in the open, and by obstructing the inflow of cold air; secondly, the grass may have had some effect on the temperature. The presence of grass alone would not seem to be responsible for the immunity from injury, as there was extensive damage to trees growing in grass on other plots. It scarcely seems likely that the height of the trees was sufficient to bring them above the layer of cold air which might have been expected to collect in this situation. It is, of course, possible that these cider varieties, even though in flower, are more resistant to frost damage than most market varieties.

Pears.—There are a comparatively small number of pear trees, of which the majority are situated about half-way up the hill-side facing north. Others occupy some of the lowest positions in the plantations. All the blossom was over and there appeared to be a good set on May 16th.

Damage to pears was comparatively slight, averaging about 25% of fruitlets blackened and killed. Towards the bottom of the slope to the east, however, there was more severe injury

Plums.—Trees of several varieties occupy one block of about 3 acres on almost level ground, at about 160 feet, while there are smaller numbers in other situations. Blossom was over and had apparently set well. In all situations there was 100% damage to all varieties, with the exception of Czar on which the injury ranged from 25% to 75%. A few seedling trees—crosses between Early Prolific and Pershore—also bore small crops although the crops on neighbouring seedling trees of different parentage were entirely lost.

Black Currants.—These cover a considerable area and are widely distributed over the plantations. Some plots consist of black currants only but in other cases the bushes are interplanted between apple trees. The majority of the blossom seemed to have set before the frost occurred. Crops were reduced by nearly 50%, and all plots containing black currants suffered to approximately the same extent. Different varieties, however, were affected in different degrees. Boskoop and Seabrook were injured to the extent of 50% and 33% respectively and several other varieties showed the same range of damage. On Baldwin, though late blossoms were killed,

the amount of damage was quite small, as fruits which had set were not affected. Westwick Choice was another variety which suffered very little.

Red Currants.—Two small plots of red currants are interplanted between bush apples. The fruits had set and no damage occurred.

Gooseberries.—There are not a large number of bushes in the plantations and they are mainly interplanted between plums and apples. On May 16th they were carrying fruit about the size of small peas. The damage done was negligible.

Raspberries and other Rubi.—Four plots in different parts of the plantations, all at low or moderate altitudes, are occupied by raspberries. At the time of the frost only the first flowers of the early varieties had opened, but there was extensive injury on every plot. On some varieties, of which Lloyd George is an outstanding example, the whole of the flower trusses were killed and the crop was nil. The young developing canes of Lloyd George were killed for a distance of about 8 inches from the tips. It is noteworthy that the varieties Preussen and Norfolk Giant growing in the same plots entirely escaped injury. Duke of Cornwall sustained 50% injury.

Differences in varietal susceptibility to frost were also very noticeable in a plot containing about 400 seedling plants of a cross between Viking and Preussen. Many of these were severely affected, while others bore full crops.

Loganberries and several varieties of blackberries are grown on a plot sloping down to the brook at the eastern end of the plantations. The earliest flowers of the loganberries were open and were killed by the frost, but the later flowers were not affected. The blackberries blossomed considerably later and there was no injury to the flowers, though there was some damage to the tips of the canes.

Strawberries.—Strawberries were growing on several plots, each of which was on almost level ground only slightly above the lowest altitude in the plantation. Plants of Royal Sovereign were well in bloom on May 16th. The whole of the flowers of this variety, both opened and unopened, were killed by the frost and the crop was a total loss. The damage in the cases of Oberschlesien and Huxley was from 10% to 25%, only the open flowers being injured. There was about 5% of injury to the flowers of Tardive de Leopold, while Pilnitz, with all the blossom still unopened, was quite uninjured.

Discussion and Summary.

The whole of the frost damage apparently took place on the night of May 16th-17th, when the screen and grass temperatures were 28°F. and 21°F. respectively. From midnight until 6 a.m. there was almost complete calm. Under these circumstances the conformation of the land would favour the collection of a body of cold, stagnant air over the whole of the lower parts of the plantations, as there is no efficient air drainage in any direction. Although the railway cutting would at first collect the cold air from parts of the plantations it does not appear to provide a channel through which a continuous flow of cold air could escape.

The data given show that damage was very severe and general over almost the whole of the area under fruit. The relative immunity from injury of the plantation on the south slope suggests that in that situation the altitude and the slope were sufficient to provide some air drainage and thus to prevent the temperature from falling as low as in other parts of the plantations.

The absence of damage in a comparatively low-lying grass orchard is remarkable: possible explanations of this have been suggested.

Different sorts of fruit were affected in different degrees, apples, plums and strawberries, on the whole, being most seriously injured. Distinct varietal differences in susceptibility to frost injury were found.

Varieties of apples showing resistance to frost included Edward VII, and, to a slight extent, Superb. Czar was the only variety of plum to show any resistance, due probably to the fact that the fruits were well set at the time of the frost. Among black currants, Baldwin and Westwick Choice suffered very little injury. Preussen and Norfolk Giant were varieties of raspberry which escaped damage, while among strawberries Pilnitz, Tardive de Leopold and Huxley were the most resistant.

No exceptionally susceptible varieties can be named as a result of the observations made at Long Ashton, as almost all the varieties except those mentioned above were very severely injured.

COMBINED WASHES.

PROGRESS REPORT.—II.

By H. G. H. KEARNS, R. W. MARSH and H. MARTIN.

I. INTRODUCTION.

For the 1935 season, a comprehensive series of field trials of combined washes was arranged upon the lines described in previous reports. Severe May frosts caused, in many trials, a total loss of crop and it was, in such trials, impossible to assess the insecticidal and fungicidal efficiencies of the experimental sprays. The trials on apple and plum in which sawfly infestation was employed as the criterion of insecticidal properties and in which apple scab was to be the index of fungicidal efficiency failed to yield full results. There is accordingly little to report in connection with these trials and the data recorded, mainly concerning phytocidal action, will be reserved for mention in the account of repeat experiments which it is intended to carry out in due course.

The present report is therefore confined to trials in which more complete results were obtained, in particular, those in which the efficiency of petroleum oil-lime sulphur combinations against capsid bug of apple and currant was tested. In addition, a description is given of preliminary work upon the utilization of derris and lonchocarpus root extracts as insecticides in combined washes.

II. HYDROCARBON OILS IN COMBINATION WITH LIME SULPHUR.

A. On Black Currants.

Field experiments in 1934 (4) showed that a combined wash consisting of a refined petroleum oil (emulsified by means of sulphite lye) and lime sulphur, applied to black currants just before the flowers opened, gave a satisfactory control of Green Capsid Bug (*Lygus pabulinus*) and did not injure the bushes. This wash aimed at the joint control of capsid and Big Bud Mite, but the high price of the oil prompted trials to ascertain whether a cheaper grade could be used without spray damage.

Two grades of petroleum oil of similar ovicidal properties were employed, the refined oil conforming to Grade G specification (6), whilst the semi-refined oil satisfied the requirements of Grade E oils. The main difference between the two oils was in percentage unsulphonated residue, that of the grade G oil being 98 per cent. and that of the grade E oil being 74 per cent. Both oils were emulsified with 20 per cent. sulphite lye (60° Tw.) (3) and readily furnished emulsions of 67 per cent. oil content which were sufficiently limpid to be poured easily. The washes applied contained 5 per cent. oil and 8 per cent. lime sulphur.

(i) *Long Ashton*. A block of black currants consisting of 1062 bushes of the varieties Baldwin, Black Tony, Westwick Choice and Blacksmith was divided into seven equal plots in a manner such that the following treatments could be applied to equal numbers of each variety :—

- (1) Unsprayed.
- (2) Grade E oil plus lime sulphur.
- (3) Grade E oil alone.
- (4) Unsprayed.
- (5) Grade G oil alone.
- (6) Grade G oil plus lime sulphur.
- (7) Lime sulphur alone.

The washes were applied on 5th April at the rate of 3 pints per bush. They dried rapidly on foliage and wood prior to a heavy rain shower three hours later. The buds on the racemes were exposed but close together and the foliage was at the “two shilling” stage.

Observations were made at regular intervals and by 24th April the plots sprayed with the Grade E oil alone or in combination with lime sulphur showed obvious signs of retarded growth, the leaves being small and the flower trusses slightly limp. The other plots showed no difference from the unsprayed plots. By mid May, the difference was more pronounced and most of the leaves receiving Grade E oil showed marginal scorch. Only a negligible amount of scorch was evident on the plots sprayed with Grade G oil and lime sulphur. The difference in growth persisted until July. Unfortunately the frost of May 17th interfered with accurate recording, but it was evident from visual observation that the use of the cheaper oil had reduced the crop.

(ii) *Thinghill*. In this trial only the Grade G oil was used, applied at 5 per cent. alone or in combination with 8 per cent. lime

sulphur to Baldwin black currants. The washes were applied on 1st April when the buds of the flower racemes were tight together coincident with the "two shilling" stage of leaf growth. The oil emulsion was applied to 34 bushes and the oil emulsion plus lime sulphur to 98 bushes under favourable spraying conditions.

The bushes were examined on 24th April and very slight damage was evident on some of the small leaves of both plots. The growth of the foliage showed no difference from that of adjacent unsprayed bushes. A final examination, on 7th July, showed that the sprayed bushes had not been adversely affected by the washes.

(iii) *Lyonshall*. A block of Baldwin black currants severely infested with Apple Capsid Bug (*Plesiocoris rugicollis*) and moderately infested with Big Bud was selected as material suitable for ascertaining the degree of control of these two pests obtained by the application of a spray containing 5 per cent. Grade G oil when the buds of the flower racemes were tight together but exposed. The wash was applied on 1st April to four rows of bushes, the bushes on either side being unsprayed.

The wash caused no damage to the bushes and the control of *P. rugicollis* was initially good. Later the effects of the spray were masked by damage caused by capsids migrating in numbers from adjacent unsprayed bushes. It was impossible, from one season's observations, to determine the control of Big Bud, and the trial will therefore be continued for a number of seasons.

B. On Apples.

In a previous report (4) the advantages secured by delaying the capsid bud burst wash until the green flower lime sulphur application were described and experiments were recorded of the safe application of the combined wash at the latter stage. It has also been suggested that an oil wash applied at the time of the hatching of red spider eggs might give the most satisfactory control of this pest.

It has been generally held that oil washes applied at, or just after, bud burst provide the best control of apple capsid and preliminary experiments at Long Ashton suggested that a satisfactory control of capsid could be secured by a combined oil-lime sulphur wash applied as late as the green flower stage. To test the latter point, this combined wash was applied, in 1935, at two centres.

(i) *Lyonshall*. A four acre block of apples infested with capsid in the previous season was divided into five equal sized plots (A, B,

C, D, E). All the trees, which were principally of the varieties Derby and Rival, were sprayed with a tar oil preparation at 6 per cent. on 10th March. On 6th April, two plots (B and D) were sprayed with a petroleum oil preparation conforming to the Grade E Type S.E. IIa specification (6) at a strength corresponding to 5 per cent. oil and, on 17th April at the green flower stage, the same plots received 3 per cent. lime sulphur. The remaining three plots (A, C, E) were sprayed, on 16th April at the early green flower stage, with a combined wash containing 5 per cent. Grade G. petroleum oil (emulsified with sulphite lye) and 3 per cent. lime sulphur. On this date no capsids were seen.

On 5th July, it was noted that there was an almost complete absence of capsid fruit markings and few leaf markings in all the plots. There was, however, a considerable amount of injury and some markings on the terminal 3 to 5 inches of the new shoots. This injury is characteristic of the capsid *Aëtiorhinus angulatus* but the identification of the species was not confirmed as the capsid had left the trees some two weeks prior to the examination. The presence of this capsid did not necessarily imply any inefficacy in the two ovicidal treatments.

Frost considerably reduced the crop, but sufficient fruit was left to enable a count to be made on 24th September. The results are summarised in Table I.

TABLE I.

Treatment.	DERBY.				RIVAL.			
	No. of Trees.	No. of Fruits.	No. and percentage of Scabbed Fruits.	No. and percentage of Capsid-marked Fruits.	No. of Trees.	No. of Fruits.	No. and percentage of Scabbed Fruits.	No. and percentage of Capsid-marked Fruits.
Combined Wash	356	7503	323 4.3%	184 2.4%	117	692	25 3.6%	5 0.7%
Petroleum Wash, followed by Lime Sulphur	217	5106	255 5.0%	174 3.4%	77	759	24 3.2%	8 1.3%

As there were no unsprayed plots, it was not possible to assess the insecticidal and fungicidal effect of the oil-lime sulphur spray. This combined wash, however, caused no spray damage and, from the results obtained, it appears probable that it was not less effective in the control of capsid and scab than the oil and lime sulphur sprays applied separately.

(ii) *Thinghill*. In collaboration with Mr. C. Savidge, Horticultural Instructor for Hereford, a block of 56 large standard trees of the variety Annie Elizabeth, severely infested with capsid, was divided into seven plots which received the following treatments :—

(Plots 1 and 7) Tar-petroleum oil preparation (conforming* to Grade D. Type S.E.) at 12 per cent., applied 21st March.

(Plots 2, 4 and 6) Tar oil preparation at 6 per cent. applied by the grower in February. Combined wash consisting of 5 per cent. Grade G petroleum oil (emulsified with sulphite lye) and 3 per cent. lime sulphur, applied at mid-green flower stage on April 23rd.

(Plots 1, 3, 5 and 7) 3 per cent. lime sulphur only on 23rd April.

The washes were applied under favourable spraying conditions and, at the green flower stage, a number of capsid nymphs were found, an indication that hatching date for the majority of the eggs was near.

Frost caused a complete loss of crop but observations of foliage damage by capsid enabled an assessment of the degree of control obtained. The combined wash on plots 2, 4 and 6 failed to give a control, for the foliage was severely attacked, to an extent equal to that on plots 3 and 5. On plots 1 and 7, the tar-petroleum oil combination applied one month earlier had provided a good control of capsid.

The successful results obtained with the combined petroleum oil-lime sulphur wash at Lyonshall and its complete failure at Thinghill may perhaps be associated with the time of application of the sprays in relation to the stage of development of the capsid egg. It is suggested that, when the capsid egg is near to hatching, the application of petroleum oil may fail to prevent emergence. In this connection it may be noted that the Baldwin black currants at the two centres were at the same stage of development on 1st April and that their growth continued the same throughout that month, an indication that the climatic conditions in the two localities were similar. It is reasonable to suppose, therefore, that the development of the capsid embryos progressed similarly throughout this period in the two centres. At Lyonshall, the petroleum oil wash applied on 16th April gave a good control of capsid ; at Thinghill, the petroleum oil wash applied on 23rd April failed. As the development of the capsid embryo during the last week of

* The neutral oil content (60.2%) was slightly lower and the percentage neutral oil soluble in dimethyl sulphate (76%) slightly higher than required in the specification.

incubation is rapid, it is possible that the difference of one week in the dates of application of the wash may be the factor determining success or failure of the control measure.

III. DERRIS EXTRACTS IN COMBINATION WITH LIME SULPHUR.

The present method of employing the ground root for the preparation of sprays based upon derris and lonchocarpus insecticides would appear, at first sight, to be amenable to improvement. If a satisfactory method were found for the extraction of the active constituents of the roots, the cost of transport of a relatively large bulk of inert material would be eliminated and the difficulties of sampling the chopped or ground root would be reduced. Such a procedure would be practicable only if it were shown (1) that the extraction process could be carried out economically upon the plantation or at some convenient central station, (2) that the extract provided an insecticide comparable in efficiency and stability to the ground root, (3) that suitable methods were available for the easy preparation of sprays from the extract.

These three requirements are at present under investigation, but the present report is concerned only with preliminary work upon points (2) and (3). It is evident that a suitable standard of reference to serve as a datum line is pre-requisite to the biological investigation of these two points. This standard should be a stable and well-defined insecticide, preferably itself a constituent of derris and lonchocarpus root. The obvious choice is rotenone. It is emphasized that the choice of rotenone is not to be interpreted as a suggestion that this material is necessarily the most suitable form of derris and lonchocarpus extract for practical use. Rotenone has been used in these preliminary tests only to establish a basis of comparison to be used in subsequent work upon the insecticidal efficiency and stability of other extracts and to determine the probable range of usefulness of the derris and lonchocarpus insecticides.

A. Control of Apple Capsid.

At Pinvin, Worcestershire, a block of twelve 30-year-old bush trees of the variety Worcester Pearmain, severely infested by the Apple Capsid Bug (*Plesiocoris rugicollis*) and appreciably attacked by Winter Moths (*Cheimatobia brumata*) was used for the comparison of the relative efficiencies of rotenone and nicotine as

constituents of the lime sulphur petal fall wash. The compositions of the washes were as follows:—

- (1) 8 oz. nicotine, 1.5 gall. lime sulphur, 1 lb. Sulphonated Lorol to 100 gallons.
- (2) 1.2 oz. rotenone, 1.18 pint acetone, 1.5 gall. lime sulphur, 1 lb. Sulphonated Lorol to 100 gallons.

The rotenone spray was prepared by the addition of an acetone solution (5.13 per cent.) of rotenone to the dilute lime sulphur—Sulphonated Lorol solution.

The washes were applied in drenching amounts on 17th May, 1934, each to four randomised trees, four trees being left unsprayed as control. Immediately after spraying small numbers of nymphal capsids and half-grown winter moth larvae were collected from the sprayed trees and kept under observation. Many of the insects collected from the rotenone-sprayed trees remained active for an hour but paralysis then set in; fifteen hours later all the capsids and larvae were moribund. The nicotine wash proved equally effective in so far as the capsids were concerned but about half of the winter moth larvae recovered and continued normal feeding.

The set of blossom on the trees was satisfactory and the total number of capsid-marked and clean fruit on each tree was ascertained during the third week of August. The results expressed as averages for the trees in each treatment are given in Table II.

TABLE II.

Spray.	Total No. of Apples.	Average Percentage Capsid-marked.	Significant Difference.
Nicotine	561	3.9	} 6.68
Rotenone	887	5.3	
Unsprayed	648	31.0	

A negligible amount of scab occurred on both sprayed and unsprayed fruit.

The results show that nicotine and rotenone, at the respective concentrations used, were equally effective when applied in conjunction with lime sulphur and Sulphonated Lorol for the control of apple capsid. The trial also showed that the thorough application of the contact wash immediately after petal fall gave an effective control of the pest.

B. Control of Apple Sawfly.

(i) *Kemerton* (1934). Previous experiments by Hey and Steer (2), Austin, Jary and Martin (1) and Kearns and Swarbrick (5) showed that ground derris root, used as a wash, provided a control of apple sawfly approximately equal to that obtained with a nicotine wash, when applied a week after petal-fall. Hey and Steer stated that "nicotine was markedly superior to derris only if applied before the beginning of hatching."

In 1934, a small field trial was made in which the efficiency of a single application of a rotenone wash was compared to that of a nicotine wash, both being applied five days before egg-hatch. In addition a number of trees were given a second application of the rotenone wash when the majority of the eggs had just hatched.

Two buffered rows of twenty 12-year-old trees of the variety Worcester Pearmain were used for the trial. One row was sprayed with the nicotine wash and the other was divided so that approximately equal numbers were singly and doubly sprayed with the rotenone wash. Five trees were left unsprayed as controls.

The composition of the washes was as follows :—

- (1) 8 oz. nicotine, 8 oz. Lethalate Wetting Preparation, 1.5 gall. lime sulphur to 100 gallons.
- (2) 1.2 oz. rotenone, 1.18 pint acetone, 8 oz. Lethalate Wetting Preparation, 1.5 gall. lime sulphur to 100 gallons.

Petal fall occurred on 24th May, and the first spray application was made on the 28th May. Eggs were hatching in numbers on 2nd June, and the second spray application was made on 4th June.

The average infestation of blossom with sawfly eggs on 28th May amounted to 18 per cent. of the flowers. The degree of sawfly control was determined on 27th and 28th June by four observers who counted total fruits and infested fruits on all the control trees and on four trees in each treatment. The results are given in Table III.

TABLE III.

	Total Fruitlets.	Percentage Sawfly- attacked Fruitlets.
Unsprayed	1069	21.0
Nicotine (single application) ..	1078	5.3
Rotenone (single application) ..	1275	8.9
Rotenone (double application) ..	876	6.2

(ii) *Long Ashton* (1934). At Long Ashton, a second trial was made in which rotenone, derris root and nicotine washes were compared. The ground derris root was used at the rate of 2.5 lb. per 100 gall. and the concentration of rotenone was adjusted to the equivalent of the laboratory estimate of the content of the root of effective insecticidal constituents. Pending the publication of analytical methods yielding estimates of the insecticidal efficiency of derris and lonchocarpus root extracts more quantitative than the estimation of crystalline rotenone, it would be premature to state the basis upon which it was concluded that the rotenone equivalent of the particular sample of derris root employed in this test at the rate of 2.5 lb. per 100 gall. was 1.2 oz. per 100 gall.

Three rows of twelve 14-year-old trees of the variety Worcester Pearmain were used for the trial, each of the following washes being applied to one row :—

- (1) 8 oz. nicotine, 1 lb. Agral N, 1.5 gall. lime sulphur to 100 galls.
- (2) 2.5 lb. ground derris root, 1 lb. Agral N, 1.5 gall. lime sulphur to 100 galls.
- (3) 1.2 oz. rotenone, 1.18 pint acetone, 1 lb. Agral N, 1.5 galls. lime sulphur to 100 galls.

A further row of twelve trees was sprayed with lime sulphur (1.5 gall. to 100 galls.) to serve as a control.

The majority of the sawfly eggs were laid by 16–20th May, full petal-fall occurring on 18th May. The washes were applied on 22nd May and, by 29th May, the majority of the eggs were hatching. Although the fruits were swelling rapidly the calyx cups were still open. A few sawfly larvae were found on 1st June and by 3rd June most of the eggs had hatched.

The degree of sawfly infestation was determined by counts of total and infested fruitlets during the third week of June. The sum totals per row, ignoring counts from end trees, are quoted in Table IV.

TABLE IV.

	Total Fruits.	Percentage Sawfly- attacked Fruits.
Control	2971	28.30
Rotenone	4770	4.84
Derris root	3977	8.20
Nicotine	4502	2.99

(iii) *Kemerton* (1935). The primary purpose of this trial was the comparison of the relative efficiency of a nicotine-lime sulphur combined wash with oil and with a water-soluble "spreader." The two washes were applied to two buffered rows, each of twenty-four trees of the variety Charles Ross, each wash being applied to half the trees in each row. An adjacent row of the same variety was sprayed with a proprietary preparation containing an emulsified derris extract for the purpose of detailed observations of the reactions of the sawfly eggs and larvae to the spray. As the purpose of this secondary experiment was not the comparison of the efficiency of the preparation relative to that of the nicotine washes and for the reason already stated, no analytical details of the preparation are given.

The compositions of the nicotine washes were as follows:—

- (1) 8 oz. nicotine, 1 gall. petroleum oil (Grade G) emulsified with 4 pints 20 per cent. sulphite lye (60°Tw.), 1.5 gall. lime sulphur to 100 galls.
- (2) 8 oz. nicotine, 8 oz. Sulphonated Lorol, 1.5 gall. lime sulphur to 100 galls.

Petal-fall occurred on 23rd May and the washes were applied on 26th May. By 3rd June, eggs were hatching in numbers on the unsprayed trees, of which sixteen were distributed in the rows. On 8th June, samples of fruitlets with egg scars were examined on sprayed and unsprayed trees. The average percentage of blossoms bearing oviposition scars was 39 per cent. on the date of application of the washes. The latter examination of the fruitlet samples revealed that, in a number of cases, the ovipositor had been inserted but no egg had been laid. This apparent oviposition occurred in 25 per cent. of the fruitlets examined and the correct figure for infestation is therefore 29 per cent. and not 39 per cent. as the first estimate indicated.

Samples of injured fruitlets picked on 8th June, 5 days after the majority of the eggs had hatched, were examined by dissection under the binocular. The results of this examination are recorded in Table V, which deals only with fruitlets in which eggs had been laid.

TABLE V.

Treatment.	No. of Un-hatched Eggs.	No. of Burrowed Larvae.	No. of Larvae.		
			Alive.	Moribund.	Dead.
Control	0	26	26	0	0
Nicotine-petroleum oil ..	0	38	1	1	36
Nicotine-S. Lorol.. ..	0	13	2	1	10
Derris preparation ..	0	38	1	1	36

Judged by the examination of the larvae, the treatments appear to have been equally effective in controlling sawfly. The important point is, however, that none of the treatments showed evidence of ovicidal action although the sprays were applied eight days before egg-hatch. The larvae died after consuming a portion of the calyx tissue. This observation was confirmed by field and laboratory tests carried out at Long Ashton, in which a derris extract of known composition was included. Unfortunately, in this latter field test, frost destroyed the crop and further observations of the efficiency of the derris extract were impossible.

The percentage of fruitlets infested with sawfly at Kemerton was ascertained on 15th July by counts of both set and fallen fruitlets on the trees. The crop was light and the infestation erratic, that on the middle trees of the rows (Group 2) being relatively high, while on the trees towards one end of the rows the infestation was lower. The percentages of infested fruits for the two groups are therefore shown separately in Table VI.

TABLE VI.

Treatment.	Tree Group.	Number of Fruitlets.	Percentage of Sawfly-infested Fruits.
Unsprayed	(1)	1581	{ 13.7
	(2)		{ 26.6
Nicotine-oil	(1)	946	{ 1.3
	(2)		{ 1.2
Nicotine-S. Lorol ..	(1)	394	-
	(2)		1.6

Conclusions.

The preliminary trials recorded above would seem to indicate that, as constituents of lime sulphur-wetter combined washes, rotenone and derris root are as effective as nicotine for the control of apple sawfly. Although further comparisons at lower concentrations are desirable, the results show that rotenone, at 1.2 oz. per 100 galls., is as effective an insecticide as nicotine at 8 oz. per 100 galls. against apple capsid and sawfly.

White oil emulsion and Sulphonated Lorol were equally effective as spreaders for a nicotine-lime sulphur wash.

SUMMARY.

1. Further experiments confirmed previous results that a wash consisting of refined white oil (98 per cent. unsulphonated residue) at 5 per cent. concentration plus 8 per cent. lime sulphur can safely be applied to black currants just before the flowers open. A wash of similar concentration but containing a less refined oil (74 per cent. unsulphonated residue) applied at the same time caused serious injury.

2. A refined white oil at 5 per cent. concentration emulsified with sulphite lye and mixed with 3 per cent. lime sulphur was applied without damage to several apple varieties at the "green-flower" stage. The control of apple capsid obtained by this application was not consistent.

3. Rotenone at 1.2 oz. per 100 galls. and derris root at 2.5 lbs. per 100 galls., as constituents of lime sulphur-wetter combined washes, proved practically as effective as nicotine at 8 oz. per 100 galls. in the control of apple sawfly.

4. Nicotine and derris controlled apple sawfly by acting as stomach poisons when applied up to 8 days before egg hatch. There was no evidence that nicotine acted as an ovicide.

ACKNOWLEDGMENT.

Thanks are due to Mr. A. Wilkins for his careful assistance in these investigations.

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INVESTIGATIONS ON EGG-KILLING WASHES.

THE OVICIDAL PROPERTIES OF LAURYL RHODANATE.

By H. G. H. KEARNS and H. MARTIN.

INTRODUCTION.

In the last account of the investigations of egg-killing washes carried out at this Station, Staniland, Tutin and Walton (8) advanced two hypotheses concerning the action of tar and petroleum oils on insect eggs. The first was that ovicidal action is due to the deposition of a uniform film, relatively non-volatile and rain-resistant, which kills the eggs by a smothering or stifling action. This hypothesis would explain the efficiency of high-boiling petroleum oils in controlling Red Spider, Capsid Bug and Winter Moth. The second hypothesis was that certain types of oil, in particular tar distillates, possess a chemical toxicity to eggs of Aphid and Sucker, eggs which are not susceptible to the physical smothering action of the oil film.

As tar oils, even of a neutral high-boiling character, are inferior to high-boiling petroleum oils in inhibiting egg hatch of Red Spider and of Capsid Bug (1), a single all-round ovicidal wash requires the incorporation of tar oils in petroleum oil. Except on certain varieties of fruit such as currant, the combined tar-petroleum oil wash is effective only at oil concentrations which frequently cause severe bud damage. Fruit growers have accordingly adopted the practice of two separate applications of egg-killing washes: the first containing tar oil for the control of Aphid, Sucker and, in part, Winter Moth; the second containing petroleum oil for the control of Winter Moth, Capsid Bug and, in part, Red Spider.

The purpose of the work to be described in the present article was the discovery of an ovicide effective against aphid and sucker eggs which could be incorporated with safety in the petroleum oil wash, thus giving a single combined wash rendering unnecessary the separate application of a tar distillate wash.

The hypothesis that the eggs of Winter Moth, Capsid Bug and

Red Spider are prevented from hatching by the oil film resulting from the application of winter washes provides a satisfactory explanation for the practical observation that the efficiency of the wash is increased if the time of application be delayed until after the true dormant period. Although experiments recorded elsewhere in this Report (pp. 37-48) indicate that ovicidal washes applied for the control of Capsid Bug immediately prior to egg hatch may be ineffective, the best time of application of the petroleum oil wash is during a period when the growing buds are susceptible to damage by tar oil washes. The tar distillate substitute should therefore be sufficiently non-phytotoxic to enable the application of the combined wash at a period later than complete dormancy yet prior to aphid egg hatch.

Of materials known to be toxic to aphid and sucker eggs, 3 : 5-dinitro-*o*-cresol and its salts, previously tried by Gimingham, Massee and Tattersfield (3) were not considered suitable because of their high phytotoxic properties. More promising appeared the observation of Murphy and Peet (7) that certain aliphatic thiocyanates (rhodanates) possessed ovicidal activity against Citrus Mealy Bug *Pseudococcus citri* Risso. These investigators did not specify the actual thiocyanates employed but, in an earlier paper (6) they stated that, although the toxicity of the compound was modified by the nature of the organic radical attached to the thiocyanate group, the differences were of degree rather than kind.

EXPERIMENTAL.

Spray Materials Used.

For the preliminary trials the rhodanate derivatives available were of materials compounded as stock emulsions with petroleum oil, placed at our disposal by Imperial Chemical Industries Ltd. and described thus :—

- I.C. 72 : Emulsion containing approximately 60 per cent. light petroleum oil, the emulsifier being Agral S.R. (10 per cent.) and the remainder water.
- I.C. 21 : A similar emulsion containing 10 per cent. organic rhodanate A (cetyl rhodanate).
- I.C. 24 : An emulsion similar to I.C. 72 but containing 5 per cent. organic rhodanate B (lauryl rhodanate).

Following the promising results with I.C. 24, other samples of the

lauryl rhodanate were submitted for test. These samples comprised:—

I.C. 96: A stock emulsion containing 60 per cent. Grade E petroleum oil (5) and 5 per cent. lauryl rhodanate.

Lauryl Rhodanate: the thiocyanate of commercial lauryl alcohol of which the predominant constituent is the dodecyl derivative, $C_{12}H_{25}SCN$.

Emulsions containing the latter material were prepared in a number of ways in order to examine the influence of method of compounding upon the ovicidal efficiency of lauryl rhodanate. In one series of trials, the compound was dissolved in a Grade E petroleum oil (P4b) and emulsified by the two-solution oleic acid method (4). Check trials were made of the oil alone when emulsified by this method. In another series the lauryl rhodanate was dissolved in the oleic acid and emulsified by the addition of this solution to a dilute solution of sodium hydroxide.

For the purpose of comparison, tar distillate washes prepared from two samples of Grade A tar oil (T 10 and T 11) were included, the two-solution oleic acid method being used for the emulsification of the oils.

Analysis of the various oil samples used gave results quoted in Table I. With reference to the various rhodanates full details of suitable analytical methods have not yet been worked out but the preliminary results have confirmed the manufacturers' statements quoted above.

TABLE I.
ANALYTICAL DATA OF SPRAY MATERIALS USED.

		I.C. 72.	I.C. 96.	P4b.	Tar Oils.	
					T10.	T11.
Neutral oil, % by weight	..	62.0	59.0	100.0	89.4	90.6
Tar acids, % by weight	..	0.0	0.0	0.0	4.1	4.0
Neutral oil :						
Sp. Gr. (60°F.)	..	0.883	0.901	0.898	1.063	1.104
Boiling range :						
10% by volume	..	347	330	348	274	267°C
50% by volume	..	382	363	378	337	324°C
80% by volume	..	—	391	394	390	365°C
Unsulphonated residue :						
% by volume	..	76	69	74	—	—
Dimethyl sulphate :						
% by volume insoluble in..		100	100	100	0	0

Analyses by methods described by Martin (5).

Laboratory Trials.

The laboratory biological examination of certain of the organic rhodanates as winter ovicides necessitated comparative tests with materials of known toxicity to the test material.

The test insects used were the eggs of Permanent Apple Aphid (*Anuraphis pomi* De Geer.) and Apple Sucker (*Psyllia mali* Schmidb.). Preliminary and confirmatory tests were carried out with the aphid over two seasons, and preliminary trials only with the sucker. The Permanent Apple Aphid was selected in preference to the other species on account of the greater ease of rearing the large stocks of uniform material essential for comparable tests. Tar oils of suitable concentrations are highly toxic to the eggs of Permanent Apple Aphid and Sucker, and field experience showed that the eggs of the various species of Apple Aphid exhibit susceptibilities of the same order to such tar oils.

The eggs were treated with two concentrations of the tar oil in the preliminary tests (Table II) in order to ascertain the concentrations required to give a high and low kill of the eggs. From these results the concentration was adjusted to give a high and moderate egg kill in the confirmatory trials. Similar tests were made with the rhodanates.

The ovicidal properties of the oil, lauryl rhodanate and oil plus lauryl rhodanate were separately ascertained, as it was known that the petroleum oil by itself provided some control of aphid eggs.

(a) *Experiments with Aphides.* Shoots bearing eggs were cut during dry weather and taken to the laboratory for treatment. The shoots were carefully selected so that each had several hundred eggs of normal and uniform appearance. Not less than 4 shoots were used for each individual test and they were dipped into the insecticide, care being taken to agitate the fluid so that any air film on the shoots or around the eggs was broken. The shoots remained in the fluid for 15 seconds. After treatment they were attached to a strip of wood which was moved in such a manner to avoid the formation of areas of high concentration of the wash during drying. The basal ends of the dried shoots were cut off and rejected and the clean ends thrust into pots filled with damp sand. The pots were allowed to remain out of doors, exposed to the weather, until the first few eggs on the untreated controls showed signs of hatching, which usually occurred 4-10 days after the outer egg membrane had split longitudinally. The shoots were then taken into the laboratory and 8 samples of each treatment (lengths of $1\frac{1}{2}$ — $2\frac{1}{2}$ in.) were cut at random.

Each of these lengths was impaled on a pin held by a cork and inserted into an open-ended tube of $5 \times \frac{5}{8}$ inch dimension. The open end was plugged with cotton wool. The twigs during the above sampling were manipulated in such a manner that none of the eggs were damaged or subjected to pressure. The tubes were arranged in trays to facilitate inspection.

The hatched nymphs in most cases wandered from the pieces of shoot and in due course died in the tube. The cotton wool plug permitted the shoot and aphides to dry out without decomposition or development of moulds.

The total number of eggs on each shoot was counted after removal by gently heating the shoot in 10% caustic soda in a water bath for about 10 minutes. Care was taken to avoid decomposition of the bark by excess heating. The eggs were filtered off and washed with weak acid solution and counted in 5 inch petri dishes over squared paper. The aphides were readily counted by shaking and brushing into a petri dish. On each piece of shoot there was not less than 100 eggs and in most cases there were 300.

In the preliminary trials (see Table II) the stock of aphid eggs was obtained from the new wood on an apple stool bed. The bed was carefully sprayed in August to remove all species of Hemiptera. The shoots were then infested with colonies of Permanent Apple Aphid, which bred very rapidly on the vigorous new growth and laid numerous eggs during October.

In the confirmatory trials (see Table III) the stool bed material failed, due to unfavourable climatic conditions, and material was therefore collected from a number of nursery trees of the variety Worcester Pearmain, considerable care being taken to collect uniform material.

In both seasons the treatments were carried out during the last week of January; hatching began at the end of March and was completed by mid-April. The majority of the eggs hatched during the first week of April.

Parasitism of the eggs was not observed during the two seasons experiments. Observations were made on the influence of the condition of the shoot on the viability of the eggs. It was found that eggs laid on weak shoots and stools, or on shoots covered with apple scab pustules were frequently of low viability. In the experiments care was taken to eliminate shoots of this type.

The high ovicidal efficiency of lauryl rhodanate against the eggs of *A. pomi* is apparent from Tables II and III. Further it will be

TABLE II.

PRELIMINARY LABORATORY TRIALS ON *A. pomi*.

Preparation.	Active constituent and concentration in wash applied.	Emulsifier.	Total number of eggs counted.	Per cent. hatched eggs.
I.C. 21	{ Rhodanate A 0.8% } { Petroleum oil (I.C. 72) 4.2% }	Agral S.R.	2012	17.3 $\pm$ 8.32
I.C. 24	{ Rhodanate B 0.4% } { Petroleum oil (I.C. 72) 4.6% }	do.	1185	1.1 $\pm$ 0.62
I.C. 72	Petroleum oil (I.C. 72)	do.	1524	35.4 $\pm$ 5.53
—	Tar oil (T.10) 2%	{ Oleic acid (0.6%) } { Sodium hydroxide (0.1%) }	1545	9.5 $\pm$ 4.52
—	Tar oil (T.10) 1%	do.	3313	44.6 $\pm$ 4.49
—	Nil	do.	{ 1876 } { 1378 }	54.3 $\pm$ 8.52 40.7 $\pm$ 5.17
—	Nil	Nil	1423	53.8 $\pm$ 5.39

TABLE III.
CONFIRMATORY LABORATORY TRIALS ON *A. pomi*.

Preparation.	Active constituent and concentration in wash applied.	Emulsifier.	Total number of eggs counted.	Per cent. hatched eggs.
I.C. 21	{ Rhodanate A 0.4% } { Petroleum oil (I.C. 72) 2.1% }	Agral S.R.	2222	15.8 ± 3.76
I.C. 24	{ Rhodanate B 0.4% } { Petroleum oil (I.C. 72) 4.6% }	do.	1620	0.6 ± 0.22
I.C. 72	Petroleum oil (I.C. 72) 5.0%	do.	2334	31.9 ± 5.03
—	{ Lauryl rhodanate 0.4% } { Petroleum oil (P4b) 5.0% }	{ Oleic acid (0.6%) } { Sodium hydroxide (0.1%) }	1961	0
—	{ Lauryl rhodanate 0.2% } { Petroleum oil (P4b) 5.0% }	do.	1797	11.5 ± 3.13
—	{ Lauryl rhodanate 0.05% } { Petroleum oil (P4b) 5.0% }	do.	2347	50.8 ± 4.07
—	Petroleum oil (P4b) 5.0%	do.	2009	35.4 ± 8.92
—	Lauryl rhodanate 0.2%	do.	2094	4.8 ± 1.63
—	Tar oil (T.11) 2.0%	do.	2621	2.7 ± 0.87
—	Tar oil (T. 11) 1.5%	do.	2990	10.7 ± 2.32
—	Benzene 2.5%	do.	1934	79.5 ± 3.37
—	Nil	Nil	3481	96.1 ± 1.49

noted that neither the addition of petroleum oil nor the various methods of compounding the washes have decreased this efficiency. In both preliminary and confirmatory trials, the cetyl derivative (Rhodanate A) proved less ovicidal than lauryl rhodanate, a result which is in agreement with the general conclusions of Bousquet, Salzberg and Dietz (2). These investigators examined the contact insecticidal action of the alkyl rhodanates upon the active stages of various species of aphides, thrips, and red spider and showed that, of the even-carbon homologues of the normal primary alkyl rhodanates, a toxicity peak occurs at the C_{12} (lauryl) derivative.

(b) *Experiments with Apple Sucker.* The sucker eggs were laid principally on old wood and a technique was evolved for handling them under laboratory conditions. The preliminary observations revealed the high toxicity of lauryl rhodanate-petroleum oil combinations at concentrations effective against aphid.

Field Trials.

A preliminary field trial was carried out on two blocks of apple trees, each of 60 nursery trees of the variety Worcester Pearmain. A lauryl rhodanate-petroleum oil combination (I.C. 96) applied at concentrations of 0.4 lauryl rhodanate and 5.0 per cent. oil on 21st February provided a high degree of control of aphides. No evidence of bud or bark damage was observed.

SUMMARY OF RESULTS.

1. Lauryl rhodanate, in two seasons' laboratory tests, has proved highly toxic to eggs of *Anuraphis pomi*, being more ovicidal at concentrations of the order of 0.4 per cent. than high-boiling neutral tar oil at 2.0 per cent.

2. The ovicidal efficiency of lauryl rhodanate is unimpaired by solution in petroleum oil and by emulsification with Agral S.R. or by the two-solution oleic acid method.

3. Preliminary trials have indicated that lauryl rhodanate is toxic to eggs of *Psyllia mali* at concentrations effective against aphid eggs.

4. A preliminary field trial of the combined lauryl rhodanate-petroleum wash has confirmed the general ovicidal efficiency of the wash and has demonstrated that it caused no injury to the sprayed trees.

ACKNOWLEDGMENTS.

Our thanks are due to Mr. A. Wilkins for his patient and careful assistance and to Imperial Chemical Industries Ltd. for the provision of samples of the organic rhodanates.

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THE INCIDENCE OF "REVERSION" IN SEEDLING BLACK CURRANTS AND IN CLONES DERIVED FROM THEM.

By G. T. SPINKS and G. E. CLOTHIER.

The infection of black currants with the disease commonly known as Reversion, and the spread of this disease, have been the subject of investigations by several workers. Amos and others (1) carried out experiments on the methods by which the disease might be transmitted from one plant to another. Amos and Hatton (2) investigated the incidence and spread of reversion in the field. Swarbrick and Thompson (3) also made observations on the incidence of the disease. All the above workers tried and discussed methods of control.

At the present time, however, the problem of obtaining stocks of black currants definitely free from disease, and of keeping them healthy, still remains. If reversion is not transmissible through the seed, seedlings free from the disease would furnish clean stock, and it is possible that clones raised from them might remain healthy for a considerable time, if safeguards against infection from an outside source were taken.

Until the observations recorded herein were made, there has been little or no information on the incidence of reversion on seedlings and clones derived from them. The following notes supply some data on these points.

On the question of the possibility of transmission of reversion through the seed the data cannot furnish a conclusive answer, since the seedlings were raised with a different object and apparently reversion-free parents were used: but that does not exclude the possibility of the presence of reversion in latent form in them.

The observations recorded here were made on individual seedling plants and on clones derived from certain selected seedlings. The seedlings were produced as the result of cross or self-fertilizing several standard varieties of black currant and were raised primarily with the object of obtaining good new varieties. Thus the material under consideration was not designed specifically for an investi-

gation of possible reversion inheritance. Nevertheless, since, when the various characters of the bushes were observed each year, any bushes seen to be reverted were noted, information bearing on this subject was accumulated as a secondary issue. The data secured may prove of value to subsequent investigators on the subject and this paper is therefore presented, although the studies have led to no striking positive conclusions. It is possible that under the circumstances an occasional isolated case of reversion was missed, but it is extremely unlikely that the number of these, if any, was sufficiently large to affect to any material degree the general nature of the statistics recorded.

It will be convenient to consider the individual seedling plants and the clone plants separately.

Bushes Grown Direct from Seed.

In the years 1920 and 1921 several families of seedlings were raised from seed obtained from the varieties Baldwin, Boskoop, French, Seabrook and Victoria. In some cases the seed was obtained from self-fertilized flowers, in other cases cross-fertilization was carried out, various combinations of the parents being made. All the parents used were free from reversion, unless the disease was present in a latent, and therefore invisible, condition.

The resulting seedlings were all planted out in one plot and observed closely from 1924, their first year of cropping, until 1926. The total number of seedling plants was 1,300.

In 1924, one seedling was noted as being "possibly" reverted but, since the symptoms were not seen on this plant in the following two years, it may not have been a case of genuine reversion.

In 1925, two bushes were found to be definitely reverted and there were three more doubtful cases, which were not confirmed in the following year. The latter therefore were probably instances of "false" reversion.

In 1926, two further definite cases of reversion were found and three doubtful cases. At the end of that year all the bushes were grubbed, since their primary service had been fulfilled.

Thus in this particular instance out of 1,300 seedling plants four were definitely reverted at the end of their fifth or sixth year of growth from the seed. Seven others were of a more doubtful order and may have been cases of "false" reversion.

In 1929, five other families were produced by the self-pollination

and crossing of selected seedlings of a previous series. These families, comprising 1,160 seedlings, were planted out in the winter of 1931-2 and were kept under observation from 1933 to 1935. One reverted seedling of this group was found in 1933 and there was also one doubtful case in the same year. A second doubtful case was noted in 1934. In 1935, no further obvious cases of reversion were noted; but observations were not made so closely in that year, since it had been decided to discard these seedlings at the end of the growing season, their purpose in other directions having been served. It is evident, however, that at least one case of reversion in this batch had occurred on a seedling after only four years growth from the seed.

Clones Raised from Seedlings and certain Commercial Varieties.

During the winter of 1928-9 a large trial plot was planted with 41 clones which had been raised from selected seedlings. The trial also included clonal plants of the commercial varieties Kent Baldwin, Hereford Baldwin and Boskoop. Most of the clones consisted of 72 bushes, arranged in three units, each containing 24 bushes, in different parts of the plot. A few clones consisted of only one or two units of 24 bushes. The total number of bushes was 2,880. At the end of 1932, four bushes in each unit were removed in order to make room for planting apple trees, and at the end of 1934 two more bushes were removed from each unit. By 1935, therefore, the number of bushes in a full unit had been reduced to 18.

The clones had been derived from two separate series of seedlings. In the one series seven clones were obtained from seedlings raised in 1916 or earlier. In 1928 reversion was noted on bushes of six of these clones. It cannot, however, be stated with certainty that no reversion had occurred before that date, no observations on this point having been made previously in this particular group. Meanwhile stocks of the clones had been increased and in 1927-8 enough cuttings were taken to provide bushes for the trial plot now under consideration.

The other series of seedling clones, 34 in number, were derived from the seedlings raised in 1920 and 1921 to which reference was made above. Cuttings from selected bushes were taken in 1924 and 1925 and stocks worked up in the following years. No reversion had been found on the selected bushes when the first cuttings were taken, but one such bush was definitely reverted in the following year and two others were doubtful cases. During the period 1925 to 1927, while stocks of this second series of clones were being increased, no observations on reversion were made in the cutting-beds.

At the end of 1927, cuttings of all the above clones were planted in order to supply the actual bushes to be used in the trial plot, and in 1928 the cutting beds were inspected for reversion, when a considerable amount was found. The plants on which reversion could be detected were pulled up and discarded. The number of cases of reversion found in each clone is given under the year 1928 in Table I.

TABLE I.
NUMBERS OF REVERTED PLANTS.

Seedling.		Cuttings.	Clone Plants in Trial Plot.							Total 1930-1935	% 1930-1935
		1928	1930	1931	1932	1933	1934	1935			
B.S.	13	—	6	2	—	—	1	3	6	}	6
B.S.	19	—	1	4	1	—	—	1	6		
B.S.	121	—	—	—	—	—	—	3	3		
O.P.	21	—	26	5	1	—	1	—	11	}	15
O.S.	24	—	2	1	—	—	—	3	4		6
P.S.	24	—	10	6	—	—	1	1	8		11
N.S.	124	—	?	2	1	—	—	—	3		4
B.F.	35	—	23	9	4	—	—	5	18	}	14
B.F.	46	—	5	—	—	—	1	—	1		
B.F.	53	—	32	9	1	1	—	1	12		
B.F.	72	—	4	7	2	—	—	1	10		
B.F.	74	—	18	5	1	—	1	1	8		
B.F.	134	—	16	2	1	—	1	6	10		
B.F.	152	—	—	1	—	2	6	5	14*		
B.F.	157	—	2	—	1	—	1	5	7		
B.F.	164	—	8	—	2	—	1	3	6		
B.P.	40	—	2	2	—	—	1	1	4	}	6
B.P.	79	—	—	—	—	—	—	1	1†		
B.P.	130	Revert (?) 1926	—	3	3	—	—	—	6		
B.P.	196	—	2	—	—	—	4	—	4		
B.V.	70	—	—	—	2	2	—	2	6†	}	7
B.V.	74	—	1	1	—	—	—	—	1*		
B.V.	79	—	—	—	1	—	—	—	1†		
B.V.	105	—	1	—	1	—	—	—	1†		
B.V.	140	—	—	—	—	—	2	4	6*		
B.V.	163	—	—	—	—	—	1	1	2†		
B.V.	173	—	—	—	—	—	1	—	1†		
B.V.	191	Revert 1925	—	—	—	—	1	1	2†		
B.V.	215	—	—	—	1	—	—	1	2		
B.V.	228	—	3	—	—	—	1	1	2†	}	6
B.V.	230	—	—	—	1	—	1	4	6		
F.B.	49	—	39	5	1	1	1	—	11	}	13
F.B.	66	—	6	4	—	—	1	3	8		
P.B.	63	—	5	—	—	2	—	3	5	}	6
P.B.	64	—	13	9	3	—	—	3	17		
P.B.	67	—	9	—	—	—	—	1	1*		
P.B.	68	—	—	—	—	—	—	—	—		
P.B.	71	Revert (?) 1926	—	4	1	—	—	—	5		
P.B.	97	—	—	—	—	—	—	2	2		
P.B.	145	—	—	—	—	—	—	1	1		
P.B.	146	—	—	—	—	—	—	2	2		
Baldwin (Hereford)		?	?	5	—	—	—	1	7		10
Baldwin (Kent)		?	?	—	2	—	—	3	7		10
Boskoop		?	?	1	2	1	—	3	10		14

* 48 bushes in the clone.

† 24

Other clones consisted of 72 bushes.

As there were considerable differences in the numbers of cuttings planted from the various seedling clones, and no records were kept of the actual numbers in individual cases, the figures for the reverted cuttings must not be taken as a true numerical indication of the relative amount of infection in the various clones. But the figures do show that some clones were seriously infected, while in others no reversion was detected or the number of infected cuttings was very small.

The clones of the two Baldwin varieties and Boskoop were not examined in the cutting bed ; but subsequent observations indicated that the number of infected cuttings could not have been high.

The plants were transferred to the trial plot as one-year bushes in 1928-9 and were cut back. In 1930 and succeeding years the plot was inspected and all reverted bushes were marked and grubbed up almost immediately after recording, so that no bushes known to be infected were left from one year to the next. The figures for 1930 to 1935 in Table I indicate the number of new cases of infected bushes found each year in the various clones.

A study of this table reveals the following facts :—

In 1930, out of a total of 2,880 bushes, 87 were found to be reverted and it is seen that, in general, the amount of infection was roughly proportional to the amount which had been found among the cuttings in 1928. Three clones, B.F. 152, B.P. 130 and P.B. 71, in which reversion had not been found in the cutting-bed, had now produced a total of eight reverted bushes. It is perhaps worthy of note that clones B.P. 130 (three reverted bushes) and P.B. 71 (four reverted bushes) were derived from seedling plants which were noted as doubtful cases of reversion in 1926. Five infected bushes were found in one clone of Baldwin and one bush among the Boskoops. In five seedling clones which were seen to be infected in 1928 no reverted bushes were found, while 14 clones which were apparently free from infection in 1928 still showed no signs of reversion.

In 1931 the number of newly-reverted bushes was smaller, the total being 33. Of these, 22 were found among 13 clones in which reversion occurred in the previous year, four in three clones reverted in 1928, and seven in five clones not previously reverted.

In 1932 only seven reverted bushes were found and five of these occurred in four clones which had shown reversion in the previous year.

In 1933 only four fresh infections were found. These occurred

in three clones which had shown reversion in one or other of the three preceding years.

In 1934 there was an increase in the number of new cases of reversion, the total being 37. Of these, five bushes occurred in four clones which had never previously shown the disease. One such clone, B.V. 191, however, was derived from a seedling found to be definitely reverted in 1925 after cuttings had been taken from it in the previous winter.

In 1935 infection was still more widespread, 80 reverted bushes being found. Of these, 10 occurred in six clones which had previously been free from infection. Only one clone, P.B. 68, among the whole of the series, had remained free from reversion up to the end of 1935, though four clones were uninfected up to the end of 1934.

Throughout the life of the plot big-bud mite had been effectively controlled by lime-sulphur spraying; though a few big buds had been found, their number was so small that no note had been taken of their situation. At the end of 1935, however, a careful inspection of the plot revealed the presence of big-bud on 48 bushes, but, with the exception of three fairly badly infected bushes, infection was very slight, being limited to one or two buds on each bush.

Big-bud occurred on 19 reverted bushes, but was also present on 29 bushes on which no reversion had been found. Since reverted bushes found in 1935 numbered 80, 61 of these were thus free from big-bud.

Discussion.

The above data have been presented in detail on account of their diverse character and their consequent bearing on the main issues with which this investigation is primarily concerned. These, put in question form, are :—

(a) Is reversion transmissible from one generation to another through the seed ?

(b) If the answer to (a) is in the negative, does the reversion-free seedling retain immunity from reversion longer than a plant raised vegetatively from a cutting from a reversion-free stock ?

(c) Is the nature of the parentage of a seedling related to the degree of susceptibility or resistance to reversion of the latter ?

No reversion was noted on seedling plants during the first three years of their life. It cannot be positively stated that it was

absent, for it may have been present in a latent form and, moreover, the plants were only observed rather superficially until they started cropping in their fourth year. A very small number of seedlings were found to be reverted in the fourth and fifth years. In view of the very large number of seedlings which remained healthy in appearance until five or six years of age it appears more probable that the few reverted bushes referred to were infected from an outside source when about three years old than that the disease had been transmitted through the seed.

Some clones derived from seedlings became heavily infected with reversion within eight years from the germination of the seedling and a considerable number of fresh cases of disease appeared in these clones in the following two years. Careful roguing out of the diseased bushes was followed by the almost complete disappearance of reversion for the next two years. After that, however, reverted bushes were again found in larger numbers and in the last year of the observations were even more numerous than in the previous year.

This reappearance of the disease might be explained in two different ways. Healthy bushes may have been newly infected with virus by insects or other means during the later years of the period of observation or, secondly, the disease may really have been latent for several years in apparently healthy bushes and only have become evident later.

A plan of the plot was made indicating the positions of the bushes which showed infection at various times. A study of this plan does not suggest that infection spread from any definite centres. In the earlier years reverted bushes were found in the largest numbers in the units of the clones which were originally most heavily infected, and these occurred scattered irregularly over the plot. In the later years, while infections were sometimes common in units which had shown a large number of reverted bushes earlier, this was not always the case. For instance, some units which were badly infected in 1929 and 1930 showed very few reverted bushes in 1934 and 1935, while in other cases units apparently healthy in the earlier years showed a fair amount of infection later. Each unit consisted of a single row of 24 bushes planted five feet apart and frequently several infected bushes were found in 1934 and 1935 at intervals along the row, while neighbouring rows showed no sign of infection.

The reappearance of symptoms of reversion in certain previously infected units, while neighbouring units remained apparently healthy, suggests that the new outbreak of disease was not due to

fresh infections and supports the theory that the disease can remain latent in the clone for a year or two. Swarbrick and Thompson (3) have already expressed the opinion that reversion may be present in a latent state.

On the other hand, in 1934 and 1935, reverted bushes occurred in clones which had never before shown signs of disease, and these appear to be genuine cases of new infections; but these were scattered all over the plot and do not point to any definite centres of infection.

In the trial plot under consideration the question of the spread of the disease is confused by the presence of such a large number of different clones which, from the available evidence, appear to vary considerably in their susceptibility to the disease. Thus, the figures in Table I indicate that, up to the present, there have been more cases of reversion in the clones of families B.F. (Baldwin x French) and F.B. (French x Baldwin) than in the families B.V. (Baldwin x Victoria), B.P. (Baldwin x Boskoop) and P.B. (Boskoop x Baldwin). This in itself suggests some difference in susceptibility, although it does not necessarily mean that the former clones are actually more susceptible: it may be that by chance they were infected at an earlier stage in the propagation of the clones and have therefore had more opportunity for producing reverted bushes.

Reviewing these points it may be concluded:—

(a) That seedlings raised from apparently reversion-free plants of the parents show no visible signs of reversion till they have reached an age when they could have become directly infected from outside sources.

(b) That plants propagated from some seedlings can apparently become infected with reversion as readily and rapidly as those from cuttings of commercial varieties.

(c) That there is some evidence that the parentage of a variety influences its degree of susceptibility or resistance to reversion.

SUMMARY.

1. Observations have been made of the incidence of reversion on about 2,500 seedling black currants and on clones derived from certain selected seedlings.

2. Reversion has been found on a few seedling black currants four years old, but the great majority remained healthy for six years.

3. Some clones derived from apparently healthy seedlings have become heavily infected with reversion within four years: others have remained almost or entirely free for ten years.

4. Systematic rogueing of infected clones for two years largely eliminated visible signs of the disease, but reverted plants appeared again after another two years.

5. It is thought that in some cases the disease may have reappeared after remaining latent for two years in infected clones. In other cases the later infections seem to be genuine new infections, although it cannot be shown that they occurred round definite centres of infection.

6. In a plot containing about 3,000 bushes no correlation has been traced between the occurrence of reversion and of big-bud, but the data on this point are rather incomplete.

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THE CONTROL OF WOOLLY APHID

(*Eriosoma lanigerum* Hausm.)

ON NURSERY TREES.

By H. G. H. KEARNS and E. UMPLEBY.

Of the numerous insect pests of the apple, Woolly Aphid is one of the most widely distributed and easily recognised (1), but it has proved most difficult to control despite the rapid increase during the past ten years in the range of efficient insecticides available to the grower.

Various control measures have been suggested and used, and these may be grouped as follows :—(a) spray materials suitable for large numbers of trees and (b) materials for application by means of hand brushing, this method being only suitable for small scale application and especially for nursery trees.

In connection with the methods already proposed there are certain points which appeared to require further investigation.

Thus under (a) two main procedures may be adopted: the immersion of young trees in a spray fluid or the application of the spray in the usual manner. A tar-oil wash has been used previously for immersion purposes on nursery trees and although good results have been reported in experiments (4), the method has not been adopted widely in actual practice, presumably because of fear of injury from what appears to be a rather drastic procedure.

The application of nicotine washes containing water-soluble wetters during the summer has failed in many instances to provide a satisfactory control of the pest on account of the difficulty of wetting the aphides protected by their wax secretions. On the other hand, nicotine in conjunction with white oil emulsions has given promising results.

Greenslade has attempted to evolve a laboratory technique for evaluation of wetters against Woolly Aphid (2).

In connection with (b) the liquids most widely used have been methylated spirit, paraffin (kerosene) and paraffin emulsions, and the results have been satisfactory provided that the applications have been thoroughly carried out and before the infestations have

been established in the green, terminal shoots. Many cases of apparent injury, however, have been noted following the use of kerosene.

Greenslade has recently tested a Canadian dressing consisting of castor oil, nicotine and flour, and found it to be satisfactory (3).

In view of the above facts, it was considered desirable to carry out experiments to test the further efficiency of the tar-oil dipping method, giving special attention to possibility of damage, and also to see whether this treatment could not be replaced by a hot water immersion method. Moreover, the use of kerosene for brush applications seemed to require further investigation to determine possible phytocidal effects, whilst the use of a nicotine-white oil emulsion spray, as a possible method of replacing brush applications, appeared worthy of examination.

Experiments were accordingly carried out during 1933-1935 in which the tar-oil dipping method, immersion in hot water, brush application of kerosene and spray applications of nicotine washes were tested.

The results have shown that the immersion of nursery stock in either tar-oil emulsion or hot water provided satisfactory results. The application of kerosene caused serious injuries to the trees and the spray application of nicotine-white oil emulsion gave a fair measure of control of the aphides.

Observations on Woolly Aphid on Nursery Stock.

In the West Country the Woolly Aphides may be found throughout the year in the crevices of cankers and other bark wounds, but the numbers are considerably lessened during the period of December to March when eggs are frequently present. The aphides at this time are readily stimulated to activity and continuous reproduction by placing infected shoots in a moderately warm moist atmosphere.

The history of the infestation of standard cider nursery stock is frequently as follows :—

Initially, the rootstock is infested and the attack extends to the side shoots of the stem builder and finally to the terminal shoots, graft union, or graft. Generally, with increasing age of the tree, the root infestation decreases and often in the third or fourth years it is of negligible proportions. During the third and subsequent years the infestation almost invariably spreads from a colony of aphides to the stem, or aphides are blown over in the wax from severely attacked trees. Occasionally the infestation of clean trees may be traced to wandering aphides ascending the stems.

It has been recognised for many years that winter spraying with tar-oil emulsions has killed many of the over-wintering aphides and their eggs. The success of the treatment is dependent upon thorough spraying, and it has been found that even under the most favourable conditions of application that the wash does not enter all the cracks in the bark in the areas of infestation, and consequently aphides survive to form the nucleus of a fresh attack during the following season.

Generally speaking efficient winter washing with tar-oils cleans up the heads of nursery trees, and it has been found that the first symptoms of re-infestation on sprayed trees usually occur on the stems during the period of April until June. If these colonies on the stems are effectively controlled the chances of a serious infestation of the head are greatly reduced. It has been found that once a tree is infested it is liable to remain so for some years unless control measures are adopted. The infestation unfortunately coincides with the first few years of the tree's life and may materially interfere with the proper development of tree shape.

Most of the observations on the susceptibility to attack have been confined to cider varieties. None appear to be free from attack and the differences in susceptibility vary considerably from season to season. Thus it was noted that the degree of infestation varied more with the location of the trees in a hillside nursery than with the varieties. Those portions of the nursery most subject to attack were, as would be expected, also most subject to infestations by Permanent Apple Aphid (*A. pomi*).

The well-known appearance of the colonies renders it unnecessary to describe them. Those portions of a tree which are developing new tissue rapidly are most subject to attack, such as grafts, freshly pruned surfaces and terminal shoots of rapidly growing trees and roots, more particularly of young trees. Severe infestations reduce the vigour of the tree and the tissues punctured by the aphides may hypertrophy into large galls. These swellings often split and permit the entry of Apple Canker spores which in the case of a young tree considerably reduces its value or may even spoil it entirely.

The attacks are of most serious consequence when they occur on nursery stock, more especially when the infestation extends to the terminal shoots and interferes with shaping the tree on account of the stunted growth of the leaders and consequent formation of weak side-shoots. This form of injury can be extremely severe on top-worked standard cider stocks.

An infestation in a nursery can become a very serious problem

unless the initial attack on the roots and stem is effectively controlled. Under suitable climatic conditions the pest is able to reproduce rapidly and become widely distributed. Thus during the past four seasons at Long Ashton, observations have shown that an infestation increases very rapidly provided there is a more or less continuous spell of 2—3 weeks' wet weather at any period during the summer, whilst late autumn attacks under West Country conditions are also frequently severe.

Hot, dry spells of weather invariably rapidly reduce the infestations. In 1935, the attacks developed during the wet weather of April, May and June, but the advent of dry weather in late July gave a rapid check to the infestations and very little was seen of the pest during August. In late September and November, the attacks became severe again, and aphid reproduction continued until finally checked by the reduction in temperature.

EXPERIMENTAL.

The experimental work was carried out principally on nursery stock and was divided into winter and summer treatments.

Winter Treatments.

(a) Immersion in Tar Oil Emulsion.

One hundred and seventeen two-year-old bush trees, consisting mainly of the varieties Cox's Orange Pippin and Worcester Pearmain on East Malling Stocks Nos. II, IX and XII and on Crab were dipped completely for not less than five minutes on the 8th January, 1934, in 10% high-boiling, neutral tar-oil emulsion (9.0% oil). The trees were allowed to drain and dry before planting in a single block at 12ft. x 12ft. intervals. Prior to dipping a number of the trees showed obvious symptoms of infestation on the roots and stems, but it was impossible to ascertain with certainty the number free from attack as the presence of adherent soil on the roots made the detection of aphides difficult. Thirty nine untreated trees were planted in an adjoining block as a control. Observations were made on the trees at intervals during the season and the following records obtained :—

April 1934.	Control Bushes.	Aphid colonies evident on stems of several trees.
	Treated Bushes.	No signs of infestation ; buds developing on all the bushes.
May 15th.	Control Bushes.	18 Trees infested = 46.1 per cent.
	Treated Bushes.	9 Trees infested = 7.7 ..
Sept. 3rd.	Control Bushes.	15 Trees infested = 38.4 ..
	Treated Bushes.	17 Trees infested = 14.5 ..

None of the trees died despite extremely bad growing conditions prevailing during the summer and no apparent difference in the growth of the treated and untreated trees was noted. The control of Woolly Aphid was not complete, 14.5 per cent. of the treated trees being infested and 38.4 per cent. of the control trees.

Detailed observations showed quite clearly that the presence of damp soil on the roots prevented contact between the tar-oil emulsion and all the aphides. Aphides and their eggs in cracks on the stems often remained unwetted unless the air and wax films covering them were broken by repeatedly lifting the infested stems in and out of the liquid. The only method that ensured intimate contact between all the aphides and eggs and the tar-oil wash was to soak the tree roots in water and remove all the soil prior to dipping.

(b) Hot Water Treatment.

The difficulty of obtaining a high control of Woolly Aphid on nursery stock by means of dipping in tar-oil emulsion made it necessary to test other methods. A preliminary experiment was carried out in which infested bush trees of mixed varieties were completely immersed in hot water at 110°F. for 30 minutes, as it had been found that this temperature and time killed Woolly Aphides and their eggs and also the eggs of other species of pests.

Seventy severely infested bush trees were selected, and of these 44 were treated on the 15th March, 1935, and 26 kept as controls. Prior to treatment as much as possible of the heavy clay soil adhering to the roots was removed by washing with running water. The bushes were planted in a trench in close proximity to each other. Observations were made at intervals during the season with the following results:—

		<i>No. of Infested Trees.</i>	<i>No. of Clean Trees.</i>	<i>Percentage of Clean Trees.</i>
May 15th.	Control Trees	.. 26	0	0
	Treated Trees	.. 0	44	100
June 12th.	Control Trees	.. 26	0	0
	Treated Trees	.. 1	43	98
October 2nd.	Control Trees	.. 26	0	0
	Treated Trees	.. 9	35	79.5

The infested bush recorded on June 12th amongst the treated bushes developed a prolific colony of aphides and later in July

many specimens were observed on the soil, and it is probable that these infested some, if not all, of the bushes recorded as attacked on October 2nd. The hot water treatment was carried out most carefully and the infestation of the one bush was due either to the failure of the treatment to kill all the aphides and eggs or alternatively to infestation from an outside source. None of the trees were harmed by the treatment, and indeed the growth was outstandingly vigorous as compared to the controls, largely due to the absence of Woolly Aphid and other pests.

Summer Treatments.

(a) Application of Kerosenes. (Paraffins.)

During some experiments in 1932 on the phytocidal properties of several grades of atomised kerosenes, it was found that samples with the lowest content of aromatic constituents and of comparatively high volatility below a temperature of 200°C. did not appear to cause any rapid or appreciable damage to apple foliage. The most satisfactory sample had the following specification:—

Specific gravity at 15°C	=	0.788
Aromatics	=	7.0%
<i>Distillation figures.</i>		
Initial boiling point	=	154°C
Volume distilled up to 200°C	=	55%
Final boiling point	=	268°C

During June and July of 1933, a number of different varieties of standard cider nursery trees were hand-painted with kerosene of the above specification. The application was only made to colonies of Woolly Aphides on the stems, though no special care was taken to avoid wetting the side shoots. Some injury was noted on the green shoots, but it was not at the time considered of any serious consequence. The control of aphides was satisfactory and a given volume of kerosene treated more trees than the same volume of methylated spirit. Records were kept on the treated trees during the autumn and following season, when it was noted that a considerable number became attacked by canker. The results suggested that the kerosene treatment had rendered the trees more subject to canker infection.

In 1935, the experiment was repeated in order to obtain more critical data. Sixty well grown standard cider nursery trees of the variety Crimson King on Crab Stock were treated on July 12th with the kerosene. The stems and base of the side shoots (feather) were completely wetted, but the heads were not touched. A



FIG. I.

A section of a stem of a standard nursery tree showing dead tissue at the base of a side shoot killed by kerosene.



FIG. II.

(a) Stem of tree killed, and (b) areas of bark injured by kerosene.

similar treatment was given to 9 trees of the variety White Alphington on Crab Stock. Small colonies of Woolly Aphid were also painted on 15 trees of the variety Sweet Alford. The kerosene dried rapidly on the trees.

Observations were made at regular intervals. Within two weeks after treatment considerable scorching of all the treated green side-shoots was noted on all varieties. This rapid appearance of extensive injury was most marked when compared with that noted in 1933 after using the same sample of kerosene. During August, 1935, the damage extended, and it was evident that considerable and permanent injury had been caused to many of the trees whose stems had been completely painted. An examination of the injury showed that the kerosene either considerably retarded the growth of, or, in a number of cases actually killed, the side shoots. Injury to the side shoots frequently extended into the stem (Fig. I), and when this occurred a dead area developed which resembled superficially apple canker. An extreme example of injury is shown in Fig. IIa, in which a tree with numerous side shoots, and therefore many centres of severe stem injury, was dead by the end of November. The most common form of injury to the bark is shown in Fig. IIb, in which the bark died in areas and finally peeled off and was replaced by new tissue. During the period of bark replacement the wound is liable to infection by canker.

A final examination of the trees was made in January, 1936, when they were divided into two groups, the first consisting of trees that had completely recovered and as far as could be judged were free from canker, and the second trees with the bark so obviously damaged as to render them unsuitable for sale. 90% of the trees were placed in the second group. The three varieties Crimson King, White Alphington and Sweet Alford were all equally damaged.

It is evident from these experiments that a kerosene more refined than many samples generally used commercially and sold as lighting paraffins caused extremely serious damage to nursery trees and hence the danger of using commercial paraffins is readily understood.

(b) Application of Methylated Spirit.

The application of methylated spirit to the stems of nursery stock has been used extensively at Long Ashton for a number of years. It has been observed that a liberal application to an older stem does no harm, but that such treatment to green or terminal shoots may cause some foliage scorch and check the growth of the shoots. In the case of the young and more delicate side shoots die-back may occur, and this may be followed by canker infection.

Spirit treatment is best confined to older stems and after the removal of green side shoots. The spirit does not cause any injury to bark wounds resulting from the removal of side shoots that have not completely callosed over.

(c) Nicotine Washes.

A field trial was carried out in the summer of 1935 in an endeavour to determine any differences in the degree of control of Woolly Aphid obtained with washes containing various wetters, including a refined white oil in conjunction with nicotine, but the infestation generally proved insufficient to make any significant comparisons.

One result, however, is worthy of record :—two applications of a refined white oil emulsion (1.0 per cent. oil) and 8 fluid ounces nicotine appeared to give a fair measure of control. The washes were applied on July 12th and 22nd.

The number of trees showing obvious symptoms of infestation before the first spraying was carried out totalled 48 : of these trees 19 were still obviously infested on August 10th. This represents a reduction of 60.4 per cent. in the infestation. A similar number of control trees showed, over the same period, a reduction of 19 per cent. infestation.

SUMMARY.

Experiments on the control of Woolly Aphid infesting nursery stock showed that :—

1. The immersion of bushes in 10 per cent. tar-oil emulsion did not provide a complete control, 14.5 per cent. of the trees being infested after treatment. None of the treated trees died and their growth did not differ from those of untreated trees.

2. A preliminary experiment in which nursery stock was immersed in hot water at 110°F. for 30 minutes provided 98 per cent. clean stock in mid-June and the treated bushes made better growth than comparable controls, presumably on account of the absence of pests.

3. The application of a refined kerosene (paraffin) to the stems and side shoots of standard cider trees caused serious injury.

4. Spray applications of a refined, white oil emulsion (1.0 per cent. oil) in conjunction with nicotine (8 flu. ozs. to 100 galls.) at an interval of ten days in the summer effected a 40.6 per cent. reduction in an infestation.

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A STRAWBERRY DISEASE RESEMBLING THE AMERICAN "CRIMP."

By L. OGILVIE and C. R. THOMPSON.*

Since 1929 the senior author has had under observation a disease of strawberries in the Cheddar area of Somerset. The symptoms on the variety Madame Kooi, which is commonly grown in that district, are as follows :—

The leaflets are markedly "ballooned," with their edges curled downwards. They are noticeably brittle, darker in colour than normal and often have transverse corrugations, especially near their bases. Sometimes the shape of the leaf may be abnormal. Large pale green areas may develop, especially at the bases of the leaflets. These areas may finally become dark brown and necrotic, while similar dead areas may often occur on the petioles. The tips of the runners may be swollen and the fruit may be somewhat abnormal in shape.

Among the diseased plants may usually be found several of the symptoms reminiscent of "red plant" of Royal Sovereign. For example the petioles tend to be devoid of hairs and the laminae reduced in size.

Experimental.

In the spring of 1935 two raised beds of steam sterilised soil were made up in a greenhouse at Long Ashton. The first bed, Plot A, measured 21 ft. by 3 ft. To $3\frac{1}{2}$ in. in depth of sterilised Long Ashton soil in this bed were added $1\frac{1}{2}$ in. of soil from an infected area at Cheddar.

The second bed, Plot B, measured 10 ft. by 3 ft. and was similar in all respects in make-up to Plot A, except that the Cheddar soil added had been previously steam sterilised.

Strawberry runners of the varieties Royal Sovereign, Oberschlesien and Madame Kooi, obtained from as healthy sources as possible and subjected to careful examination, were warm water treated by the usual method (110°F. for 20 minutes) and were planted in the beds in equal numbers of each variety, the plants

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being six inches apart, on April 3rd (Sovereign and Oberschlesien), and April 11th (Kooi). There were 148 plants in Plot A, and 76 in Plot B. The soil was ridged between the rows so that water tended to run on to the crowns of the plants; the beds being kept well watered.

Results.

Detailed observations were made on the plants on April 29th and May 15th, with the results shown in the following table. (Table I).

TABLE I.

	Plot A (+ Cheddar Soil).				Plot B (+ Sterilised Cheddar Soil).			
	Crimp.		Red Plant.		Crimp.		Red Plant.	
	April 29	May 15	April 29	May 15	April 29	May 15	April 29	May 15
Sovereign ..	11	17	1	2	—	—	None	
Oberschlesien	9	23	—	—	2	6		
Kooi ..	3	16	—	3	—	8		
Totals ..	23 (16%)	56 (38%)	1 (0.7%)	4 (4%)	2 (3%)	14 (18%)		

It will be seen that the symptoms described above as occurring in the Cheddar area, and referred to here as "crimp" symptoms, occurred in much greater amount in Plot A than in Plot B.

It was found as the summer progressed that many of the previously affected plants produced healthy leaves. The experiment was continued till spring 1936, and it was then found that many of the diseased plants had recovered while others previously healthy were producing distorted leaves.

Suggested Cause of the Disease.

Examination of diseased Kooi plants from Cheddar in June, 1933, revealed the presence of numerous nematodes among the heart leaves in the youngest buds and in brown areas at the bases of the petioles. Specimens were submitted to Dr. T. Goodey, who replied in a letter dated June 4th, 1933, "The nematodes in the

blotched areas of the strawberry leaves are *Aphelenchoides fragariae*. As a rule this species is ectoparasitic on strawberries, but I have found it endoparasitic in strawberry leaves with distortion and discolouration of the blade. Marcinowski and Goffart in Germany also found it endoparasitic in strawberry leaves."

Careful inoculation experiments are necessary before it can be proved that the nematode is the cause of the "crimp" symptoms. The trial described above appears to show that the agency is at any rate soil-borne. The fact that some crimp developed in Plot B is probably to be explained by the failure of the ordinary hot water treatment for strawberries (110°F. for 20 minutes) to kill the nematodes, as has been shown recently by English workers.

Two American publications, dated 1931, by Brooks and Stevens respectively (1, 2), describe a disease known there as "crimp" or "dwarf," the symptoms of which resemble strikingly those described above. These authors agree that the most conspicuous symptom is the malformation it induces in the young leaves as they develop. According to Brooks the leaves are crimped, crinkled* and cupped. The tips of young leaves and stipules of severely diseased plants show a dry and brown condition. The green colour of both young and old leaves is darker than normal and they are more brittle. The petioles are usually less pubescent than normally, in fact almost glabrous.

All these symptomatic details of "crimp" were reproduced in the plants under observation. In the case of the Sovereigns in the plots the crimping or ballooning symptoms were often combined with red plant symptoms, *i.e.* glabrous petioles and marked dwarfing of the young leaves, while in the field crimping of the older leaves is usually associated with red plant symptoms in the heart. In fact, although in the table the plants are differentiated into those in which "crimp" predominated and those in which red plant predominated, all gradations may be found between "crimp" and "red plant" symptoms. It is of interest that Brooks suggests that the "red plant" of English workers may be caused by the same agency as "crimp."

Brooks and Stevens claim that typical crimp plants have been produced by inoculation of nematodes into the buds of healthy plants. In our opinion another indication that the trouble is actually caused by nematodes is the development of dead brown areas on the leaves and petioles of affected plants of varieties with rather fleshy leaves such as Kooi. As already mentioned the

* "Crimp" should be distinguished from "crinkle." (See Long Ashton Annual Report, 1933, p. 96.)



FIG. I.
Strawberry Plants (Madame Kooi) affected with "Crimp." Cheddar.



FIG II.
Strawberry Runners (Madame Kooi) affected with "Crimp." Cheddar.

nematodes have been found in these areas and the appearance of the areas strongly resembles the lesions produced on leaves of chrysanthemums and other plants by the closely related nematodes *Aphelenchoides Ritzema-Bosi* and *A. olesistus*.

It may be noted that no typical "cauliflower plants" were found, either in the affected fields at Cheddar or in the experimental plots.

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THE CONTROL OF FLEA BEETLES BY MEANS OF A SEED DRESSING.

PROGRESS REPORT.

By C. L. WALTON.

The losses caused to agricultural, horticultural and garden Brassicae crops through the attacks of various species of Flea Beetle are only too well known, and until recently little beyond cultural practices were available for their control. Two articles have recently appeared describing successful control methods involving the use of derris and naphthalene dusts on horticultural crops (5), (6), but it must be realised that methods suitable to horticultural practice are not necessarily applicable to agricultural conditions, particularly on farms where wide areas of swede, kale, etc., are grown. Few farmers as yet possess machinery suitable for large scale applications, whilst the cost of carrying out wet or dry sprayings is greater than many crops can bear.

These latter points became clear during preliminary field trials in 1933, and it was therefore decided to concentrate later upon the use of a seed dressing, especially on one evolved by the writer and Dr. H. G. H. Kearns.

Numerous field trials with this preparation were carried out on farm Brassicae crops during 1934 and 1935 and comprised series of tests with the complete dressing and also with the separate ingredients.

As a result the conclusion was reached that the dressing affords a satisfactory means of protection during the seedling stages.

Previous Work with Seed Dressings.

Other attempts have been made in this country along these lines with some measure of success, the substances used being paraffin and turpentine.

Corbett (1) tested the effect of turpentine and paraffin on turnip seed, following the suggestion that they could be used in warding off flea beetle attack; Jenkins (2) carried out field trials and concluded that, although the method was dependent for its success

upon favourable conditions, given the conditions, a high degree of control may be obtained. He also found that treated seed in almost every case showed slightly higher germination than the untreated. The Ministry of Agriculture Advisory Leaflet 109 (3) of April, 1932, states that "it is often claimed that dressing the seed with paraffin or turpentine is of great value in preventing an attack. One fluid ounce (about 2 tablespoonsful) of oil is sufficient for 7 lb. of seed. The seed should be treated just before drilling."

Newton (4) as the result of experiments carried out at Wye during the period 1924-26 concluded that "seed steeping in paraffin and turpentine gave negative results—further trials of water soluble steeps is suggested."

In view of the above results and conclusions it was felt that a further attempt should be made to evolve, if possible, a seed dressing of a more effective and lasting type.

The Species of Flea Beetles Attacking Farm Crops.

An examination of 25 samples of beetles taken on swede and kale at farm centres showed that the most abundant species in the Bristol Advisory Province is undoubtedly *Phyllotreta undulata*, Kutsch, which occurred at 17 centres. *Plectroscelis* (*Chaetocnema*) *concinna*, Mm., occurred 6 times; *P. atra*, F., once; *P. ochripes*, Curtis, twice; and *P. consobrina*, Curtis, once. *P. cruciferae*, Goeze, is abundant on cabbage, cauliflower, etc., throughout the Province.

EXPERIMENTAL.

The Composition, Preparation, and Use of the Seed Dressing.

The dressing used in this series of experiments consisted of a mixture of paradichlor-benzene and naphthalene dissolved in a kerosene. It was found by experiment that small crystals of naphthalene failed to adhere to the seed, and therefore it was necessary to adjust the proportions of the solids in the solvent to avoid the formation of crystals. The following formula has been found to be satisfactory as regards adhesion to the seeds of various Brassicae and storage over long periods. The formula, giving costs, is as follows:—

						Cost. s. d.
Kerosene	1 gallon	..	..	..		1 6
Paradichlorbenzene	4 lb. ..	..	..	..		4 0
Naphthalene	1 lb. ..	..	..	..		4
						5 10

The paradichlorbenzene used is a commercial grade, and the naphthalene is in the form of crude creosote salts. The kerosene conformed to the following specification :—

Specific Gravity (15°C)	..	..	0.785
Distillation range—			
Initial B.P.	..	..	166°C.
34% distills at	..	..	200°C.
Final B.P.	..	..	280°C.
Aromatics	..	..	7%

It is probable that an unrefined kerosene would be equally satisfactory, since its main function is to act as a solvent, whilst it has been found by repeated experiments that crude kerosenes (paraffin) do not reduce percentage germination.

In farm practice the cost of this seed dressing is very small, and in any case should not exceed $1\frac{1}{2}$ d. to 2d. per acre for ingredients. Two tablespoonsful = 1 fluid ounce, are generally used to each pound of seed. Most farmers who have used the dressing found that dressed seed “ran” well in the drill, whilst some others have said that it was “a bit sticky.” This latter condition was usually due to uneven distribution, and was easily obviated by treating the seed on the day before drilling, the dressed seed being spread out on sacking overnight in order to remove excess.

Field Trials.

Field Trials in 1933. In 1933 trials were carried out on crops of swede, kale and turnip at sixteen centres, and were distributed over all the counties of the Advisory Province.

The treatments, in addition to the seed dressing above described, included (a) a bariumfluosilicate dust, (b) a naphthalene dust, (c) a derris dust, (d) naphthalene drilled with the seed. Of the 16 centres used, eight failed to yield results, either through absence of infestation, or owing to the effects of a series of violent thunderstorms which literally washed away several of the treated plots. In the remaining eight, however, it was evident that the seed dressing not only showed promise as a protective against beetle attack but provided a more numerous “plant.”

Counts showed that up to the time of “singling” there was a markedly higher average number of plants on the dressed than on the control plots, and this was commented upon by several of the farmers concerned.

Mr. A. Murchie made a comparative count at seven centres in Somerset, and counting the number of plants, generally in the

"rough leaf" stage, on an equal number of 10 yard lengths, he obtained the following figures :—

<i>Crop.</i>	<i>Number of Plants.</i>	
	<i>Treated rows.</i>	<i>Untreated rows.</i>
Kale	6,276	3,273
Swede	3,743	2,426
Turnip	7,578	2,201
	17,597	7,900

These results were distinct from any effect of protection from flea beetle attack, and were confirmed by subsequent counts in 1934 and 1935.

As examples of the protection afforded by the seed dressing against the beetles, the following may be quoted :—

		<i>Percentage attack.</i>	
	<i>Crop.</i>	<i>Dressed seed.</i>	<i>Untreated seed.</i>
1. Upper Slaughter, Glos. ..	Kale	3%	53%
2. Wheddon, Som.	Kale	50% slight.	100% severe.
3. Cannington, Som.	Swede	Moderate crop, some injury.	No crop.

Field Trials in 1934. Trials were arranged at 10 centres in the counties of Gloucester, Somerset and Worcester, and in these seed dressings only were employed. At several centres orthodichlorobenzene alone was used, but did not give encouraging results.

The trials suffered severely from drought conditions, germination being greatly delayed at most centres, whilst at several the crops remained in the "seed leaf" stage until killed by heat and drought. Flea beetle infestation reached phenomenal proportions. Despite the drawbacks, some indications of control from the seed dressing were obtained, but quantitative results were not possible.

Field Trials in 1935. Trials were arranged at 10 centres, and in all cases the seed dressing, together with instructions, was given to the farmers concerned, who subsequently carried out all operations, since it was desired that the tests should be made as nearly as possible under routine farm conditions.

Throughout this series of trials, the method used by Petherbridge and Thomas (5) for recording degrees of infestation was adopted, using figures to indicate the condition of the plant in each plot, the value 100 being assigned to a perfectly clean plot. The figures, together with the number of plants per foot length of drill, give an indication of the extent of the attack on each plot. The numbers of plants shown in the table below are the averages of random series of such counts.

Omitting five centres where infestation was either absent or only very slight, the results obtained at the remainder are shown below :—

<i>Centre.</i>	<i>Crop.</i>	<i>Condition of Crop.</i>		<i>Average number of plants per foot of drill.</i>	
		<i>Dressed seed.</i>	<i>Untreated seed.</i>	<i>Dressed seed.</i>	<i>Untreated seed.</i>
1. Barrow Gurney, Som.	Kale	90	10	—	—
2. Wrington, Som. ..	Kale & Swede	75	40	16.0	9.4
3. Langford, Som. ..	Swede	90	75	—	—
4. Burrington, Som. ..	Swede	80	0	17.0	1.0
5. Yeovil, Som. ..	Swede	95	85	7.9	3.1
	Averages	86	42	13.6	4.5

DISCUSSION OF RESULTS.

The work was hampered by the exceptional heat and drought experienced in 1934 and 1935, which resulted in a number of trials being nullified, since the seed remained dormant for prolonged periods, whilst in others the plants did not develop beyond the seedling stage. Several other trials were spoilt through torrential thunder storms, whilst at a number of centres flea beetle infestation failed to materialise, or was so slight as to preclude reliable figures being obtained.

In 1935, it was found difficult to visit widespread centres at the appropriate time and this necessitated arranging as many as possible within easy reach of the Research Station.

It will be seen from the foregoing that, despite exceptionally adverse conditions, the results have been favourable in a sufficient number of cases to warrant the method being recommended, and more especially for agricultural practice, where the application of both wet and dry sprays is generally precluded both as regards cost and lack of suitable means of application.

It is obvious that the method will not succeed equally in all cases, especially where dressed seed is sown in a hot, dry seed bed and where such conditions are prolonged. The dressing is designed to be effective over a considerable period after sowing, and experience has shown that the effects are operative sufficiently long to enable the young plant to reach the "rough leaf" stage in a majority of cases: after that the plants are usually reasonably safe from further attack.

Early underground attacks by Flea Beetles may occur, as pointed out by Newton (4) and Petherbridge and Thomas (5), and this is particularly likely where the ground is in a rather rough condition. The latter state "It is possible for this attack to occur without any Flea Beetles having been seen above ground. Such an attack occurs in April, is often very serious, and is generally ascribed to frost." It is noteworthy that in no case has there been any such attack on dressed seed during the progress of these trials.

The action of the dressing may be described as protective, but whether the terms "repellant" or "deterrent" are applicable is doubtful, since it is open to question whether the protection is afforded by proving inimical to the insect, or through a masking of the naturally attractive odour.

A number of growers stated that the dressed seed germinated somewhat more quickly than the untreated, but this was certainly not noted in all cases.

Finally, most of the growers who used the dressing expressed themselves as markedly in favour of its use.

SUMMARY.

1. An attempt has been made to provide a seed dressing which under average farm conditions will afford sufficient protection to enable seedling plants of the field Brassicae crops to reach the "rough leaf" stage without serious attack by Flea Beetles.

2. The treatment is designed more especially to afford a cheap method applicable to agricultural practice, where application of dry or wet sprays cannot be economically made.

3. The dressing used consists of a mixture of paradichlorobenzene and naphthalene dissolved in a kerosene, the cost of the ingredients, as purchased, being 5s. 10d. per gallon.

4. The amount used varied between $\frac{1}{2}$ and 1 fluid oz. to each pound of seed sown. Used at the higher rate the cost of materials should not exceed 2d. per acre.

5. The dressing has been successful in preventing or reducing Flea Beetle injuries in a considerable number of the field trials during 1933-34-35, despite weather conditions which were in many cases very adverse.

6. No case of injury to seed was noted, whilst a feature of the field trials was an appreciable increase in the average number of seedling plants per foot run of drill in the dressed rows as compared with the untreated.

7. The protection afforded was effective in all trials during the germination period, and was sufficiently prolonged in the majority of cases to enable the plants to attain the "rough leaf" condition and survive Flea Beetle attack.

ACKNOWLEDGMENTS.

Thanks are due to Dr. H. G. H. Kearns and Dr. H. Martin for assistance and suggestions, especially on the chemical aspects of the work; also to the County Organisers and their Staffs for help in arranging and supervising field trials, particularly during 1933-34, and to the farmers concerned for their willing co-operation.

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A NOTE ON MELASOMA POPULI L.
(CHRYSEMELIDAE)
AS A PEST OF BASKET WILLOWS.

By H. G. H. KEARNS.

The large Chrysomelid beetle *Melasoma populi* is at times found in numbers on poplars, but it is only occasionally seen in this country as a pest of basket willows. In 1934 and 1935 a severe infestation on a willow bed at Athelney, Somerset, consisting of a number of species of *Salix*, afforded an opportunity of making some observations on the habits of the insect and also of developing a method for its control. It was found that derris was highly toxic to the beetles and that lead arsenate used in conjunction with a suitable concentration of a wetter killed the larvae.

The Life History of the Beetle.

In 1935, the beetles left their hibernation quarters during the month of May, and it appeared from the infestation studied that many had spent the winter in the cracks between and beneath a layer of cut stones covering a raised earthen railway bank. The beetles as they emerged from their winter quarters appeared to reach the willows by walking to a bed of *Salix purpurea*, variety Dickey Meadows.

They attacked the new shoots growing from the stools, and in some instances consumed the buds as fast as they developed, with the result that the stools were unable to develop any shoots until the adult stage had died out after egg laying. The stools less severely attacked frequently produced rods with numerous side shoots (Plate I), these latter developing as a result of the beetles feeding on the terminal portions of the young shoots.

Eggs were laid in numbers during the latter part of May and in June, the majority in early June, and occasional batches were found as late as the third week in July. The beetles died soon after oviposition and the sexes seemed to be present in approximately equal numbers judging from a count of 500.

The eggs were laid in batches on the leaf surface in somewhat irregular order, the numbers in the batches varying from 29—51.

Most of the eggs were cemented on end to the leaf surface but occasionally a few were cemented on top of a batch. They were on an average 2.1 mm. $\times$ 0.8 mm. in size and of oblong, ovate shape with a smooth glistening egg shell of a uniform, light chocolate brown colour when first laid, but as the incubative period progressed a lighter outer zone became distinguishable from the inner, darker embryo. Ten females, kept on a host plant in an insect cage, laid on an average 178 eggs, though it is probable that under natural conditions the number might have been greater as it was noted that the captive females did not eat as much as they normally do.

The incubative period varied from 7—10 days. All the eggs of a given batch hatched on the same day and the larvae consumed part of the egg shells. There were three larval stages. The first instar lasted for 2—4 days and the larvae kept together and fed on the upper and lower epidermis and mesophyll of the leaf. The second instar was of 6 days' duration and usually on the third day the larvae separated and spread to various portions of the plant. The third instar—fully grown specimens were on an average 16 mm. long by 4.5 mm. wide at the first abdominal segment—continued for ten days, and during that period considerable quantities of leaf tissue were consumed. The larvae, in shape and colour, resembled very closely those of the beetle *Phyllodecta vitellinae* (1), and in common with that species developed protrusible, eversible glands. In the first instar only the meso- and meta-thoracic glands were externally evident, and in the second and third instars the first seven abdominal segments developed active glands. These glands produced, more especially with full-grown larvae, a copious quantity of a secretion which possessed the characteristic odour of an aldehyde, which was most evident on walking through the attacked willow bed. The pupal period was 7—12 days and was passed just below the surface of the soil. Large numbers of the freshly emerged beetles were found during the third week of July, 1934, and 1935. Under field conditions there was considerable overlapping of the various stages of the insect's life history. Thus beetles (from hibernation), eggs, larvae and freshly emerged beetles could be found in numbers at the end of June.

The freshly emerged beetles fed principally on the upper portions of the rods. At first they consumed the leaves and then, despite the fact that numerous lower leaves were left unattacked, they peeled the terminal portion of the rods (Plate II).

The beetles and larvae were found only on beds of *Salix purpurea*, and none were discovered feeding on adjacent beds of *Salix triandra*, *S. viminalis*, *S. Daphnoides* and other species. They were noted



PLATE I.

Development of side shoots as a result of terminal injury
to the rods of *Salix purpurea* by *Melasma populi*.



PLATE II.

Terminal portions of the rods of *Salix purpurea* peeled
by the beetle, *Melasma populi*.

feeding in July and August on Docks, Bindweed (*Polygonum arvensis*) and Yellow Rattle (*Rhinanthus Christa-galli*) growing between the stools of *S. purpurea*.

It was noticed in the second season of severe infestation that a small bed of *S. purpurea*, situated at a distance of half a mile from the first attacked bed, the intervening space being occupied by beds containing other willow species, was showing signs of infestation. It appeared that the beetles were able to travel considerable distances either by flight, walking or possibly floating on rubbish at the flood periods.

Damage caused by the Pest and Methods of Control.

The details of the type of damage caused to the basket willow *Salix purpurea* have been described above and some idea of the extent of the damage which may occur will be obtained from the following account.

The beetle was first noted in numbers by the grower in 1933, but it was not until the following season that the infestation became so severe that a quarter acre bed was entirely spoiled, mainly by the adults feeding on the basal shoots of the stools in May. A large number of stools died out in the winter of 1934—1935 as a result of the attacks in the previous season. The extreme rapidity with which the beetles bred up and became of economic importance in the dry seasons of 1933-1934 suggests that the presence of the pest in districts in which *Salix purpurea* is extensively grown may quickly lead to serious losses of crop.

Laboratory toxicity tests showed that the beetle is readily killed by a wash containing not less than 0.0025 per cent. crystalline rotenone. The larvae, particularly when fully grown, were not so readily killed by a derris wash, and the application of lead arsenate to the foliage proved to be a more certain method of controlling them.

The infested bed was sprayed on June 27th, 1934, with a combined wash consisting of derris root, 4 lbs. of lead arsenate powder and a proprietary wetter added to 100 gallons water, the concentration of the wetter being adjusted so that a satisfactory deposit of the lead arsenate was obtained on the foliage.

The wash killed by contact action considerable numbers of beetles and of those that escaped many more were killed by the arsenate. Many of the larvae collected a week after the spraying died, presumably by eating the arsenate on the foliage.

Suggested Spray Programme.

The above observations showed that the wash might provide a good control of the pest if applied at the correct time. Moreover, it would appear from the data available on the life history of the insect, together with the results obtained on the control of *P. vitellinae* (1), a willow beetle of similar habits in many respects, that a satisfactory spray programme might be possible. It is suggested that several applications of a derris wash containing not less than 0.0025 per cent. crystalline rotenone should be applied as soon as large numbers of the beetles collect on the stools in spring. Later on application of the combined wash should be given, approximately in mid-June, as a means of controlling the larvae and killing egg-laying beetles. It is important that the wash be applied so as to cover the lower surfaces of the leaves with the arsenate.

ACKNOWLEDGMENTS.

Thanks are due to Mr. G. G. Musgrave, Stoke St. Gregory, Taunton, for reporting the infestation, and to Dr. H. Martin for the preparation of the rotenone washes used in the series of toxicity trials.

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THE EFFECT OF CALCIUM CYANAMIDE ON PEA AND POTATO "SICKNESS."

By C. L. WALTON, L. OGILVIE and P. W. BRIAN.

In the Long Ashton Annual Report for 1934 (9) are described some preliminary experiments on the effect of calcium cyanamide on pea "sickness," which disease is associated with infestation of the roots of the plants by the eelworm *Heterodera schachtii*. The results indicated that applications of this chemical to heavily infested soil may result in normal cropping. It was shown, however, that there was no very marked reduction in the number of eelworm cysts as a result of cyanamide treatments.

The object of the present experiments was to bring forward further proof of the beneficial effects obtainable from applications of calcium cyanamide both in the case of pea sickness and of potato sickness, the latter being associated with a different strain of the eelworm. It was desired also to indicate whether the beneficial effects are attributable to a lethal action of the chemical on the eelworm or to its manurial value.

Summary of Previous Work.

A perusal of the extensive literature on *Heterodera schachtii* shows that in several cases good results have been recorded on potatoes from applications of calcium cyanamide. Thus Edwards (5) found that an increased crop of 2 tons per acre followed applications of calcium cyanamide at 10 cwt. per acre to potato sick land. Again Miles (7) obtained increased yields from applications of $\frac{3}{4}$ cwt. per acre, and Hodson (1934) observed beneficial effects from applications of 6 cwt. per acre. In none of these cases is there any statement regarding any reduction in the number of cysts.

It may be noted, however, that Morgan (8) obtained normal yields in field experiments, and Buckhurst and Fryer (2) in pot experiments from applications of naphthalene but no marked reduction in cyst numbers, while Davies (1933) in field experiments obtained good yields from calcium cyanamide in spite of heavy infestation of cysts on the roots. Carroll (3), however, reports a reduction in number of cysts in pot experiments from the use of calcium cyanamide.

In the recent detailed laboratory and pot work of Hurst and Triffitt (6), it was found that calcium cyanamide had no stimulatory effect on the hatching of cysts and that there was no evidence of the neutralization or decomposition of root excretions, which normally stimulate hatching, by the cyanamide. In their pot experiments they obtained no reduction in cyst numbers on potato plants from applications of less than 20 cwt. per acre.

Urea, the normal decomposition product of calcium cyanamide, produced some delay in hatching, but the cysts subsequently hatched as freely as without treatment.

On the other hand, very large dressings of cyanamide had a toxic and possibly lethal effect on embryonated eggs and larvae in cysts, and an advanced decomposition product of urea, apparently ammonia, was lethal to the larvae under certain moisture conditions in closed petri dishes.

As a result of their pot experiments, Buckhurst and Fryer (2) concluded that "sickness is due to an attack by the eelworm in conjunction with a soil factor that inhibits a vigorous early growth of roots" and that "it is possible that this second factor is a nutritional defect which is not made good by the ordinary manurial measures adopted in potato growing districts." It is also suggested (p. 600) that "it is not impossible that one or other of the essential mineral constituents, probably nitrogen, is not sufficiently available to the plant in its early stages of growth."

Another factor which has to be taken into account is the delayed germination of cysts which is apparently induced by certain chemicals and which takes place, for instance, as shown by Carroll and McMahon (4), when cysts are added to soil soon after it has been sterilised. This factor would account in some cases for the production of apparently healthy plants with plentiful cysts on their roots, but does not in our opinion suffice to explain results such as are detailed below.

EXPERIMENTAL.

Field trials were laid down at three centres, Berkeley School, Gloucestershire, the Gardens of Ston Easton Park, Somerset, and the Gardens of Fishponds Mental Hospital, Bristol. The first two localities were infested with the pea strain of *Heterodera schachtii* and the last with the potato strain.

Pot experiments were also carried out at Long Ashton.

A. Berkeley School.

In this trial the ground was known from observations in previous years to be uniformly infested with the eelworm.

Size of Plots. There were two adjacent plots, the area of Plot I being 96 square yards and of Plot II 40 square yards.

Treatment:

Plot 1. Calcium cyanamide, 10 cwt. per acre or about 22 lbs. per plot, applied on February 20th.

Plot 2. Control. No treatment.

The pea seeds, of the variety Admiral Beatty, were sown on March 20th, in three rows running through both plots, at the rate of 1 pint per row.

Appearance of Plants. June 25th. Plot I. Most of the plants were green and healthy looking. Average height 30 inches. Pods 4 inches long.

Plot II. Plants very yellow, lower leaves shrivelling. Stems spindly. Average height 14 inches.

Cyst Numbers. Although eelworm cysts were present on the roots of the plants on both plots, there were rather less on Plot I than on Plot II.

Crop Weights.

<i>Rows</i>					
<i>Plot 1.</i>	1	..	1 $\frac{1}{4}$ lbs.	}	Total 11 $\frac{3}{4}$ lbs.
	2	..	4 lbs.		
	3	..	6 $\frac{1}{2}$ lbs.		
<i>Plot 2.</i>	1	..	Only 5 pods	}	16 pods in all (=about 8 oz.).
	2	..	„ 5 „		
	3	..	„ 6 „		

It should be noted that crop weights were somewhat reduced by drought conditions in 1935.

B. Ston Easton Park.

Here also the trial was laid down on ground known from previous experience to be heavily infested. A plot 20 square yards in area was treated with calcium cyanamide at 10 cwt. per acre on February 4th. This plot and an adjoining one were sown with peas of the variety British Lion.

The results at this centre were rendered of less value owing to crop weights not being available. On the plot to which calcium cyana-

mide had been applied quite normal growth resulted but *very numerous eelworm cysts were present*, as was also the case on the control plot which, however, showed decided symptoms of "sickness."

C. Bristol.

In this case the trials were laid down in two widely separated fields in the grounds of Bristol Mental Hospital. These had both been known from previous observations to be heavily infested with the potato strain of *Heterodera schachtii*. In both trials applications of calcium cyanamide were made to certain plots at the usual rate of 10 cwt. per acre, while other plots were left untreated. In the first trial there were also two plots to which applications were made of quicklime and urea, the first decomposition products of calcium cyanamide, in quantities equivalent to 10 cwt. calcium cyanamide per acre.

TRIAL A. Size of Plots. There were five plots, each plot measuring 20 × 12 yards.

Treatments.

- Plot 1. Calcium cyanamide, 10 cwt. per acre or $\frac{1}{2}$ cwt. per plot, applied on February 12th.
- Plot 2. Quicklime, 6.3 cwt. per acre or 35 lbs. per plot, applied on February 12th, followed by Urea, 4.4 cwt. per acre or 25 lbs. per plot, applied on April 17th.
- Plot 3. Control. No treatment.
- Plot 4. Calcium cyanamide, as in Plot 1.
- Plot 5. Quicklime followed by Urea, as in Plot 2.

Well sprouted potatoes, of the variety King George V. were planted evenly in the plots on May 3rd.

Appearance of Plants. There was a noticeable difference in the growth of the plants in the various plots, those in the control plots being much yellower than the others.

Cyst Numbers. There was no obvious difference in the number of cysts on the roots, the plants on all the plots being heavily infested.

Crop Weights.

Plot No.	Crop Weights, lb. per Plot.			Calculated Crop Weights, Tons per Acre.		
1	733 lbs.	..	..	6.5 tons.		
2	825 lbs.	..	..	7.4 tons.		
3	556 lbs.	..	..	4.9 tons.		
4	577 lbs.	..	..	5.1 tons.		
5	701 lbs.	..	..	6.3 tons.		

TRIAL B. *Size of Plots.* There were four plots, each plot measuring 10 × 10 yards.

Treatments.

- Plot 1.* Calcium cyanamide, 10 cwt. per acre or $\frac{1}{4}$ cwt. per plot, applied on February 12th.
Plot 2. Control.
Plot 3. Control.
Plot 4. Calcium cyanamide, as in Plot 1.

Non-sprouted potatoes of the variety Majestic were planted evenly in the plots on May 3rd.

Appearance of Plants and Cyst Numbers. As in Trial A.

Crop Weights.

<i>Plots.</i>				<i>Crop Weights, lb. per Plot.</i>		<i>Calculated Crop Weights, Tons per Acre.</i>	
1	..	..	..	371 lbs.	..	..	8 tons.
2	..	..	..	347 lbs.	..	..	7.5 tons.
3	..	..	..	219 lbs.	..	..	4.7 tons.
4	..	..	..	510 lbs.	..	..	11 tons.

It will be seen that in Trial A the cyanamide applications gave an average yield of about 5.8 tons per acre, or an increase of about 1 ton per acre over the control plot, and that in Trial B there was an average yield of about 9.5 tons per acre on the treated plots, or an average increase of about 3.4 tons per acre over the control plots.

In Trial A, the lime followed by urea plots yielded an average of 6.8 tons per acre, compared with 5.8 tons from the cyanamide plots.

To summarise, satisfactory crop weights were obtained from the plots treated with calcium cyanamide and from those treated with lime followed by urea, while the control plots gave poor yields. There was a marked infestation with eelworm cysts, however, in all the plots.

D. Pot Experiments.

In these experiments there were 30 pots of soil; 10 pots of Long Ashton soil and 20 pots of mixed soil composed of equal quantities of Long Ashton soil and potato sick soil from the Bristol trial centre.

Treatments. The pots were divided into three series as follows :—

1. 10 pots infested soil.
2. 10 „ Long Ashton soil.
3. 10 „ infested soil dressed with calcium cyanamide at 10 cwt. per acre.

All the pots received a dressing equivalent to superphosphate at 3 cwt. per acre and sulphate of potash at $1\frac{1}{2}$ cwt. per acre. Sprouted tubers were planted in the pots on the 1st April, 1935, but as most were killed by frost late in May, all the plants were removed from the pots, which were replanted with Majestic tubers, on 23rd May.

Results. In August, the plants in pots of Series 1 (infested soil) showed markedly poorer growth of haulm and were very yellow. The tubers were lifted and weighed on October 18th, the summarised results being as follows:—

		<i>No. of Tubers per Series.</i>		<i>Total Weight of Tubers.</i>	
Series 1.	Infested soil	67		3.12	kilos.
„ 2.	Long Ashton soil	130		4.36	„
„ 3.	Infested soil & cyanamide	117		4.18	„

Cyst Numbers. The amount of root infestation by *Heterodera* was not noticeably different in Series 1 and 3.

It will be seen that the cyanamide applications raised the crop yield appreciably towards the level of the clean soil.

DISCUSSION.

The trials described above indicate that in the case of peas and potatoes normal crops may be produced on “sick” soil following applications of calcium cyanamide at 10 cwt. per acre. Under field conditions, however, a marked reduction in cyst numbers is not usually observable.

The accumulated evidence therefore appears to suggest, as already indicated by Buckhurst and Fryer (2) and by Blenkinsop (1), that the good effects following the application of certain chemicals under field conditions are attributable not necessarily to marked lethal effects on the eelworms themselves but to a restoration of certain essential chemicals, in many cases apparently nitrogenous, to the “sick” plants.

SUMMARY.

1. Following applications of calcium cyanamide at 10 cwt. per acre, normal crops of peas and potatoes were produced on “eelworm-sick” land.

2. The cyst numbers on the roots were not appreciably reduced by the applications.

3. It is considered that the good results from calcium cyanamide are not due to any lethal effects of the chemical on the eelworms but to the supplying of nitrogen to the "sick" plants.

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THE INCIDENCE OF CANKER IN YOUNG CIDER APPLE TREES.

By E. UMPLEBY and T. SWARBRICK.

Apple canker is frequently the cause of serious economic loss to nurserymen and fruit growers. It may be regarded as the most serious disease that the nurseryman has to contend with and many are the efforts that have been made to develop a satisfactory means of control. During the last four or five years, it has been noticed that the incidence of apple canker in the Bristol Province has been unusually prevalent both in the nursery and in young trees planted out in farm orchards and fruit plantations. Cider apple trees both in the nursery and in the farm orchard have also suffered more severely than usual, and numerous cases are on record within the Bristol Province where there has been serious loss of trees during the first or second year after planting out. In the latter cases, it should be pointed out that such trees showed no visible signs of canker when they were sent out from the nurseries, although the symptoms of the disease were clearly shown in some cases within a few months after planting, but in others not until the following summer. This unusual prevalence of canker during recent years has given a new impetus to research into the possible control of the disease in the nursery and the present paper places on record some observations made in the nurseries at Long Ashton Research Station during the last three years with this end in view. The observations are confined entirely to cider varieties.

Observations both in the Station nursery and in young trees planted out in farm orchards suggest that there are two forms or manifestations of apple canker. The one which enters either through a bud or wound and causes the well-known "canker" is by far the most prevalent and serious. There is, however, another form which, for the time being, may be referred to as "Paper" canker. Its symptoms are large sunken areas of bark usually along the main stem, the bark in the more advanced stages becoming pale in colour and peeling off in thin paper-like layers. No opinion is here advanced as to whether these two symptoms are the result of the same or different organisms. The important point is that in farm orchards both forms of canker occur and both are followed by serious losses of trees.

EXPERIMENTAL OBSERVATIONS.

The incidence of apple canker in cider trees has been under observation for several years, but during the period 1932-34 a unique opportunity for the study of this problem presented itself in a large series of bush cider apples which were being propagated for experimental work at Long Ashton. The main bulk of this series of trees was made up of 35 of the better known cider varieties, each variety being propagated on two rootstocks, Seedling Crab and English Broad Leaf Paradise (M. I.). Four of the varieties were also propagated on the very dwarfing rootstock M. IX. The number of trees of each variety was not uniform, but approximately the same number of trees of each sort was worked upon each of the two main rootstocks.

The stocks used were in excellent condition and had made good growth considering the abnormally dry seasons. They were budded in July, 1932, and the bud failures grafted in spring, 1933. The "take" of buds was a little below normal due to a severe attack of the "Red Bud Borer" (*Thomasiniana Oculiperda* Rübe.), the ravages of which may be very serious on occasions. Measures for its control have been described by Staniland and Umpleby (1). The "take" of grafts was well up to average.

Both the first and second years' growth of the trees were satisfactory, but very early during the second growing season, *i.e.* 1935, the symptoms of apple canker were found on a number of trees. The number of affected trees subsequent to this increased rapidly and the removal of many became necessary. Since the block was composed entirely of cider varieties mainly on two different rootstocks, it was decided to make a careful survey of the incidence of the disease. The records of this survey are set out in Table I.

It is shown in Table I that out of the 35 varieties only 11 have not shown any canker. Of these the numbers of trees of Eggleton Styre, Fair Maid of Devon, London Red, Red Jersey, Star of Devon and Tremlett's Bitter were so small as to preclude any reliable conclusions relative to their resistance to the disease. The varieties Ellis Bitter and Royal Wilding showed no canker and Silver Cup very little and, since these varieties were all present in relatively large numbers, the results suggest that all three varieties are highly resistant to the disease. The varieties Knotted Kernel and Sweet Alford both showed less than 1.5% of canker infection in a total of 374 and 394 trees respectively, whilst Stoke Red showed only 2.5% in a total of 323 trees. The low figures for these varieties indicate that they also are highly resistant to canker infection.

TABLE I.

BUSH CIDER TREES. Budded 1933; Grafted 1934.

Number of cankered trees, August 17th, 1935.

<i>Name of Variety.</i>	<i>On Crab.</i>			<i>On M. I.</i>			<i>On M. IX.</i>		
	<i>Total No. of Trees.</i>	<i>Cank- ered Trees.</i>	<i>Per- centage.</i>	<i>Total No. of Trees.</i>	<i>Cank- ered Trees.</i>	<i>Per- centage.</i>	<i>Total No. of Trees.</i>	<i>Cank- ered Trees.</i>	<i>Per- centage.</i>
Broadleaf Norman ..	80	6	7.50	63	4	6.34	0	0	Nil
Bulmer's Norman ..	81	7	8.75	83	5	6.02	0	0	Nil
Chisel Jersey ..	45	0	Nil	33	2	6.06	0	0	Nil
Cap of Liberty ..	20	4	20.00	30	0	Nil	0	0	Nil
Dabinett ..	205	20	9.75	196	16	8.16	108	2	1.94
Dymock Red ..	22	0	Nil	31	0	Nil	0	0	Nil
Dove ..	20	0	Nil	23	0	Nil	0	0	Nil
Ellis Bitter ..	60	0	Nil	59	0	Nil	0	0	Nil
Eggleton Styre ..	6	0	Nil	5	0	Nil	0	0	Nil
Foxwhelp ..	72	2	2.77	64	0	Nil	0	0	Nil
Frederick ..	43	2	4.65	58	1	1.72	0	0	Nil
Fair Maid of Devon ..	8	0	Nil	9	0	Nil	0	0	Nil
Knotted Kernel ..	177	1	0.56	197	2	1.01	100	3	3.00
Kingston Black ..	131	56	42.74	139	55	39.56	81	11	13.58
London Red ..	13	0	Nil	11	0	Nil	0	0	Nil
Medaille d'Or ..	12	2	3.84	52	3	5.76	0	0	Nil
Michelin ..	31	0	Nil	19	1	5.26	0	0	Nil
Perthyre(Belle Norman)	90	2	2.22	76	5	6.57	0	0	Nil
Royal Wilding ..	53	0	Nil	32	0	Nil	0	0	Nil
Reine de Pommes ..	86	5	5.81	72	4	5.55	0	0	Nil
Reinette Obry ..	33	3	9.09	37	13	35.13	0	0	Nil
Red Jersey ..	8	0	Nil	10	0	Nil	0	0	Nil
Sweet Alford ..	216	3	1.38	178	3	1.68	94	5	5.31
Stoke Red ..	158	4	2.53	165	4	2.42	88	4	4.54
Sherrington Norman ..	39	2	5.12	20	2	10.00	0	0	Nil
Silver Cup ..	64	0	Nil	55	1	1.81	0	0	Nil
Slack Ma Girdle ..	37	3	8.10	40	2	5.00	0	0	Nil
Star of Devon ..	10	0	Nil	11	0	Nil	0	0	Nil
Tardive Forestier ..	69	4	5.79	65	4	6.15	0	0	Nil
Tremlett's Bitter ..	5	0	Nil	4	0	Nil	0	0	Nil
White Jersey ..	47	1	2.12	32	1	3.12	0	0	Nil
White Close Pippin ..	75	5	6.66	65	2	3.07	0	0	Nil
Woodbine ..	18	0	Nil	17	0	Nil	0	0	Nil
White Norman ..	14	1	7.14	15	0	Nil	0	0	Nil
Yarlington Mill ..	57	1	1.75	53	0	Nil	0	0	Nil

Kingston Black is outstanding as a canker susceptible variety with a figure of 40% of infected trees out of a total of 269 trees. The variety Cap of Liberty shows the high infection figure of 20% for the trees on Crab but no cases for the trees on M. I. This point of the possible effect of rootstock upon canker susceptibility is discussed in a later paragraph. The variety Reinette Obry must also be specially mentioned since it shows the second highest infection figure. This result was quite unexpected and quite contrary to previous experience with this variety. A careful examination failed to reveal any extenuating factors, such as proximity to the Kingston Black trees, so that the particular result must be accepted without qualification, but in view of previous experience, it requires confirmation. The remaining varieties all showed canker infections ranging between 3 and 7%.

From Table I it is shown that, with two exceptions, there is not much difference between the amount of infection on the trees on the two rootstocks, Seedling Crab and Broad Leaf Paradise (M. I.). These exceptions are the varieties Cap of Liberty and Reinette Obry. In the one case there is a much heavier infection on the trees on Crab whereas in the other the heavy infection is on the trees on the Paradise rootstock. No important conclusion can be drawn as to differential stock effects from the data of the trees worked upon the very dwarfing rootstock M. IX. In the case of Kingston Black, the percentage infection is much lower on M. IX—13% as against 40%—than on the other two rootstocks, and in the case of Dabinett there is also a lower figure for the trees on M. IX. In the case of Sweet Alford and Stoke Red, the figures for M. IX are slightly higher. These latter differences, however, are neither great nor important.

GENERAL DISCUSSION.

In all cases so far discussed it was the more common form of canker that occurred. In most instances the attack was in the main stem, but in the variety Kingston Black the current year's growth was also frequently infected. The sudden appearance of the disease, its general distribution over the plot and the virulence of the attack were extraordinary. In many cases, particularly in Kingston Black, the stem or the attacked shoot was completely girdled within a few weeks after the symptoms were recorded.

The results presented in this paper have a distinct bearing upon the work that has been in progress at Long Ashton for some years with a view to discovering the most suitable varieties to use as "stem builders" for the production of certain varieties of cider apple trees. It was the common practice 70-80 years ago to headwork cider varieties either direct on to Seedling Crab stocks that had been run up for the purpose, or else to plant in the orchard varieties such as Morgan Sweet or some local variety with a reputation for making strong, vigorous trees, and to headwork these to the desired variety. For a number of years now the usually recommended varieties of "stem builders" have been tried out at Long Ashton along with others that showed promise. The desirable qualities in a stem builder are a combination of resistance to canker infection, capacity for vigorous growth and firm textured wood.

As the result of continued observation and experiment the three varieties Bulmer's Norman, Sweet Alford, and White Alphonson are now used almost exclusively at Long Ashton as stem builders.

Seedling rootstocks are worked at ground level to one or other of these varieties which are then grown to a height of 6ft. 6in. when they are headworked with the required scion variety such as Kingston Black or Dabinett. Of the above three varieties used as stem builders, Bulmer's Norman, which is probably synonymous with White Muscadet, undoubtedly provides the best combination of the three qualities required in a stem builder. It is a strong grower, making as much as 8-9 feet of growth in the two years following grafting, and gives trees with an excellent "taper." The present study shows that, while not so highly resistant as some varieties, it shows a reasonable resistance to canker infection. When budded on to Seedling Crab at ground level the "take" is always good and when used for head working with other varieties it always gives a good take of grafts. The variety Sweet Alford is a very quick grower, even more so than Bulmer's Norman, but the growth is slender by comparison and the trees lack "taper." Both in previous experience and in the present case Sweet Alford has proved to be highly resistant to canker infection. It also takes grafts very well. The variety White Alphington is a very sturdy grower but not so vigorous as Bulmer's Norman. It was not included in this trial and hence no data relative to resistance to canker infection are available, but it shows a reasonable degree of resistance to the disease. Other varieties such as Morgan Sweet have been discarded because of canker susceptibility and others such as Ilminster and Woodbine show promise, but are still only in the trial stage.

The varieties, Kingston Black, Cap of Liberty, Cowarne Red, Frederick and others that are known to be extremely subject to canker should always be headworked on to a canker resistant stem builder. An experiment was carried out at Long Ashton a few years ago to demonstrate this point. 100 trees of Kingston Black were grafted in the usual manner on to Seedling Crab. Of these, nearly 50% developed canker on their main stems during the three years after grafting. Of the remainder only 10% made good trees, suitable for planting out in farm orchards. By using a stem builder such as Bulmer's Norman the percentage of good trees was as high as 70-75%.

It is intended to carry out further investigations into the control of apple canker in varieties such as Kingston Black by the method of double working, both whilst the trees are in the nursery and after the stem builders have been established in their permanent quarters in the farm orchard.

SUMMARY AND CONCLUSIONS.

1. Observations on a block of cider varieties at Long Ashton showed the following differences in the incidence of canker.
2. The varieties Eggleton Styre, Fair Maid of Devon, London Red, Red Jersey, Star of Devon, and Tremlett's Bitter remained free from canker, but the number of trees was too small to allow of definite conclusions being drawn.
3. Ellis Bitter and Royal Wilding showed no canker in approximately 100 trees of each variety. Silver Cup also showed a high degree of resistance.
4. Knotted Kernel, Sweet Alford and Stoke Red all showed less than 3% of canker infections in over 400 trees of Knotted Kernel and Sweet Alford and 300 trees of Stoke Red.
5. Kingston Black showed over 40% infections in a total of 250 trees.
6. There was no clear effect of rootstock upon canker infections—rootstocks being Seedling Crab, Broad Leaf Paradise, (M. I) and Jaune de Metz, (M. IX.)
7. The records are in agreement with previous experience of these cider varieties and confirm the choice of Bulmer's Norman and Sweet Alford as suitable varieties for use as stem builders for canker susceptible varieties such as Kingston Black, Cap of Liberty, etc. Others may also prove equally valuable in this respect.

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A NOTE ON THE OCCURRENCE OF NEW VIRUS DISEASES OF THE TOMATO IN THE BRISTOL PROVINCE.

By L. OGILVIE.

Reference has been made in recent issues of this Journal to the occurrence of Spotted Wilt of the Tomato in the Bristol Province. This disease is widespread throughout the area, but occurs mainly in "mixed" houses in which it is found on many kinds of ornamental plants.

Tomato growers may now have to reckon with two other virus diseases, both of which were found during 1935 for the first time in this area and which have been investigated by Dr. K. M. Smith (2, 3, 4), to whom specimens were submitted.

Symptoms of the Diseases.

The first disease was observed in a nursery in Gloucestershire on April 2nd, 1935. The general impression gained from a superficial examination of the plants was that cultivation was in some way at fault. There was also a possibility in this particular case that cresylic acid treatment of the soil might have been responsible for the symptoms, but conclusive evidence was eventually obtained that the main trouble was a virus disease.

On the rather mature plants in question an almost complete cessation of growth had taken place. Many of the upper leaves showed a bright yellow mottling, while the lower ones had become chlorotic and tended to drop off. The most characteristic feature, however, was a blue or purplish colouration of the entire foliage of the plant. The fruits which had been formed were usually markedly blotched and mottled.

Smith's inoculation experiments and the writer's later observations indicate that on young plants there is usually a preliminary yellowing of the edges of the young leaves, which subsequently gradually assume the bluish or purplish colouration. Smith found that, associated with the disease, there is often a dying off of the roots and the stem base.

The detailed work of Smith (3) has shown that this disease is definitely new and that the virus which causes it is not closely related to other known viruses of the tomato. It has been transmitted to several other plants, on which it sometimes forms concentric rings, as does Spotted Wilt. The new virus, however, does not produce on tomato the characteristic leaf bronzing of the latter disease. Natural infections of the new disease on other plants or on weeds have not yet been observed. Seed transmission does not appear to take place and the insects, if any, responsible for carrying it are not known. The virus, however, is readily transmitted by rubbing, as are most other tomato diseases.

The second disease was found in June, 1935, in commercial nurseries at Bath, Cheddar and Frome. Young affected plants have leaves of a faint greyish tint which are mottled with clearly defined areas of yellowish white and dark green. This mottling is peculiar: it is more pronounced than in the case of ordinary tomato mosaic, but there are none of the bright yellow areas characteristic of *Aucuba* mosaic. A different set of symptoms appears to develop when infection takes place at a late stage in growth. Under these circumstances the lowest leaves commence to turn yellow near their edges and this yellowing gradually progresses towards the midrib till only the veins remain green. In some cases complete side branches become yellow and wilt as if abscised from the main stem. The yellowing of the leaves progresses upwards to the younger foliage and the plants stop growing and may finally wilt off. When wilted, the leaves often become purplish at their edges. The fruit is in most cases much mottled and may show some necrosis.

In the case of this disease the most striking feature on mature plants and one which is immediately evident to anyone examining affected houses, is the progressive yellowing of the leaves from the base to the tip of the plant, a feature which might easily be attributed to some mineral deficiency by an uncritical observer, the symptoms resembling in many ways those due to magnesium shortage.

Smith's work (4) has indicated that this second virus belongs to the Tobacco virus group, as do several other of the tomato viruses, but details of the biology of the disease are not yet forthcoming.

Discussion.

Arising out of the information given above, there are two points of considerable importance to the grower which require emphasis.

The first is the similarity of the symptoms of these diseases to symptoms attributable to cold, faulty cultivation, drought or over-watering, mineral deficiencies, or scorching due to such agencies as leaky boilers or creosote and other fumes. Where the grower is in any doubt regarding such symptoms he should consult an advisory officer without delay.

The second point concerns the transmission of tomato diseases from tobacco. Several viruses can cause severe symptoms in both tomato and tobacco. It has been known for some years that cured tobacco may contain such viruses, and it has been proved that outbreaks of virus diseases in tobacco fields and in tobacco houses may be initiated by the use of infected tobacco by workers. Thus in a recent investigation at Cheshunt Research Station (1) twenty-one samples of cigarettes, four samples of pipe tobacco and one cigar were tested. Virus was detected in twenty of the cigarette samples, two of the pipe tobacco samples and in the cigar.

A worker who is smoking tobacco or cigarettes in the houses or who has recently done so is very liable to infect his plants simply by touching them, and it would therefore seem advisable for growers to prohibit smoking in the houses and to insist on workers washing their hands in soap and water before touching the plants. This procedure has been found to remove virus contamination effectively.

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SCLEROTINIA WILT OF THE HOP.

By L. OGILVIE.

Early in June, 1935, a peculiar wilting of hop vines was reported from Herefordshire. It had been first noticed by growers about June 10th and had rapidly become more prevalent. The disease was subsequently found in some thirty yards, mainly within a radius of ten miles from Ledbury, but also in several yards in the neighbourhood of Worcester. In some cases the loss of vine amounted to about fifty per cent., but in others it was much less.

Incubation of the original diseased material showed that the cause of the disease was *Sclerotinia Sclerotiorum*, a fungus not previously recorded from hops either in this country or elsewhere.

Symptoms.

If a wilted vine be examined carefully a straw coloured area several inches long can be found, usually near the ground. This part of the vine is at first green and watersoaked owing to invasion by the fungus. If the vine be slit down lengthwise the mycelium of the fungus can be found in the inside, extending a little beyond the diseased area. In the later stages of attack one or more black sausage-shaped bodies about $\frac{1}{4}$ " in length can usually be found in the central cavity (Fig. 1), these being the sclerotia or resting bodies of the fungus. They are at first white and covered with drops of moisture, and later become black and shining. If cut open they are found to be white and hard inside.

Cause of the Disease.

The fungus in question is a well-known one. It is responsible for a prevalent disease of potatoes in Ireland and has been recorded from a large range of crops in this country, such as tomatoes, lettuces, beans, marrows, mangolds, carrots, parsnips, etc. (See Ministry of Agriculture Leaflet No. 265.) In the United States it causes much loss to vegetables under storage conditions. During the summer of 1935 it was prevalent in Gloucestershire in commercial lettuce plantings, in which it brings about the disease known in America as "drop." It also caused damage to raspberries and commercial chrysanthemums in the Bristol Province,

besides attacking many garden plants, such as anchusas, Canterbury bells, honesty, poppies, larkspurs, mulleins and snapdragons. Sclerotia formed in the pith of these plants are often much larger than in the hop.

Course of Epidemic.

The sclerotia of the fungus *Sclerotinia Sclerotiorum* give rise, in early summer in this country, to small brown cup or disc-shaped bodies known as apothecia, which produce clouds of minute spores. These are forcibly discharged into the air, the intermittent discharge from a single cup lasting several weeks.

In the case under consideration it is possible that the disease had occurred in local hop yards in previous years to some slight extent ; indeed such is the opinion of a prominent grower.

An important factor in the epidemic was probably the development of the fungus on weeds in the headlands. Thus in 1935, in the headlands adjoining the most severely affected yards, nettles were badly attacked and large numbers of sclerotia were being produced. The fungus was also found on hemlock and hogweed.

The sclerotia produced on these weeds in 1934 probably gave rise in late May of 1935 to apothecia which shot off millions of spores, which were carried by wind all over the adjoining yards. About that time (May 17th) two or three late frosts were responsible for injuring the bines, killing off the leaves and leaf-stalks near the tips.

It has been found by previous investigators, such as Pethybridge (2), who investigated the disease caused by *Sclerotinia Sclerotiorum* on potatoes in Ireland, and by Dowson (1), who investigated the occurrence of the fungus on snapdragons in England, that the spores will not readily infect normal, healthy plant tissues but only those which have been injured or are in a moribund condition, or are without a cuticle, such as parts of flowers. It is therefore not surprising that wholesale infection took place on the frost-injured areas of the bines.

In June, 1935, a number of weeds growing in the yards, such as groundsel, chickweed and convolvulus, were also infected. Some weeks afterwards the " hills " were earthed up, with the result that the fungus mycelium developed profusely on the half-rotting weeds under the ground and spread from them to as yet unaffected bines, causing still further wilting. The development of fungus mycelium and sclerotia on the exterior of such bines under the ground is seen in Fig. 2. Mr. C. Savidge, Horticultural Adviser for Hereford, also noted that large numbers of slugs were attracted and injured

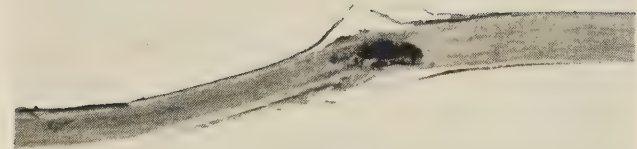


FIG. 1. Affected hop bine cut lengthwise showing sclerotium.

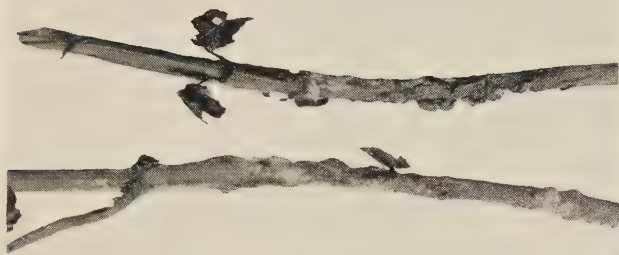


FIG. 2. Affected parts of bines from under soil, showing development of mycelium and sclerotia on outside of bine.

healthy bines, thus rendering these more liable to attack by the fungus. Healthy bines touching diseased ones even several feet above the ground were also infected by contact.

It was found that even where no special control measures were being attempted, little fresh damage developed after the beginning of July. This was probably because the production of spores from apothecia was becoming less abundant and the bines had recovered sufficiently from frost effects to resist the fungus. Dry conditions also helped to check the growth of the mycelium and to prevent further infection by contact.

Control Measures Recommended.

It was pointed out at the time of the epidemic that it was most important to uncover all earthed-up "hills" in yards where the disease was present, to allow drying up of affected bines to take place. It was also recommended that diseased bines be cut out and burned. It is important that such material be completely destroyed, otherwise copious sclerotia may subsequently develop.

As will be realised from the information given above, the adequate suppression of weeds both in the yards and in the headlands is of great importance, as in the case of other diseases of the hop. It is possible also that deep cultivation may be of value in burying the sclerotia.

It is impossible to foretell whether or not the disease will recur to an epidemic degree in 1936. Much will depend on the weather conditions in early summer. Growers, however, will be well advised to carry out the sanitation measures suggested above, to delay earthing up and to apply the other treatments recommended in the event of an attack.

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- (1) DOWSON, W. J. A blossom wilt and stem rot of cultivated *Antirrhinums* and *Schizanthus* due to *Sclerotinia Sclerotiorum*. *Journ. Roy. Hort. Soc.*, 51, p. 252, 1926.
- (2) PETHYBRIDGE, G. H. Investigations on Potato Diseases (Reports 1—7). *Journ. Dept. Agric. and Techn. Instruc. for Ireland*, 10—16, 1910—16.

PROGRESS REPORT ON VEGETABLE DISEASES.—VII.

By L. OGILVIE and P. W. BRIAN.

The following report deals with work on Vegetable Diseases in the Bristol Province carried out during the season 1934-1935, and is a continuation of those published previously.

LETTUCE DISEASES.

Mosaic Disease.

Mosaic disease of lettuces has been referred to in our 1933 and 1934 reports. Probably owing to the mild winters, which were conducive to the spread of aphides, this disease was very prevalent on winter lettuces in the springs of the years 1933 to 1935.

With a view to ascertaining the response of various varieties of lettuces to mosaic, variety trials of winter-hardy cabbage lettuces were laid down at Long Ashton and at Winterbourne, near Bristol, the latter with the co-operation of the Gloucestershire County Council horticultural staff. Observations were made on these and other trials in May, 1935, with the results summarised in the accompanying tables.

In view of the marked differences in the severity of symptoms on different varieties it became necessary to study the whole problem of the classification of cabbage lettuces. This was done by P. W. Brian, who formed the opinion that existing schemes of classification were inadequate and who has proposed a new grouping of varieties.* The varieties given in the following tables are arranged according to Brian's classification.

* See Brian, P.W., Varieties of Cabbage Lettuce and their Classification. *Journ. Pom. and Hort. Sci.*, Vol. XIV, p. 26, 1936.

TABLE I.

- * (A) Frenchay. (E) Long Ashton.
 (B) do. (F) Birlingham, Worcs.
 (C) Winterbourne.
 (D) Cheltenham.

Group No.	Variety of Lettuce.	Symptoms.	Incidence in Trials.* (per cent. infection).
1.	<i>All the Year Round Types.</i> All the Year Round ..	Very severe. Much stunted. Leaves mottled, pale and folded.	33 (C).
	Feltham King	Hearting not badly affected. Plants stunted and yellow. Veins cleared.	(C). No quantitative data.
	Spring Beauty	Not severe. Rather pale and rather poorly hearted.	70 (A), 54 (B), 54 (D).

In the *All the Year Round* Group mosaic symptoms are not uniform. All the Year Round is severely affected, while Feltham King and Spring Beauty are so little affected that affected plants are usually saleable.

Group No.	Variety of Lettuce.	Symptoms.	Incidence in Trials. (per cent. infection).
2.	<i>May Queen Types.</i> May Queen	Affected plants conspicuously mottled. Poor hearting. Stunted	31 (C), 83 (D).
	May King	ditto.	(C). No quantitative data.
	Winter Victor	Badly affected, yellow and flat. Leaves crinkled. Hearting badly affected.	75 (D).
	Loos Tennisball	Pale, crinkled leaves, edges waxy, veins cleared. Plant stunted.	24 (F).

In the *May Queen* Group the varieties observed are badly affected.

TABLE I—continued.

<i>Group No.</i>	<i>Variety of Lettuce.</i>	<i>Symptoms.</i>	<i>Incidence in Trials. (per cent. infection).</i>
3.	<i>Trocadero Types.</i>		
	Trocadero	Plants small and pale. Leaves crinkled and hearts small. Not marked.	15 (A), 14 (B), 29 (C).
	Green Trocadero	Slight paling and failure to heart. Heart leaves crinkled. Slightly stunted.	21 (A) 72 (B).
	Camb. No. 1	do.	15 (A) 28 (B).
	Improved Unrivalled	Impossible to distinguish properly. Slightly pale, no stunting.	52 (D).
	All Seasons	Slight paling, small. Little reduction in hearting.	16 (A), 32 (B), 59 (C).
	Premium	Affected plants not very conspicuous, but pale, crinkled and rather small.	60 (A), 68 (B), 35 (C), 32 (F).
	Harrison's Perfection	Slightly stunted and pale. Hearting not much reduced.	46 (E).
	Improved Trocadero	Affected plants small, yellow, mottled. Poor hearts.	14 (C), 69 (D).
	Unrivalled	Leaves pale, heart leaves crinkled. Stunt- in most cases.	26 (A), 44 (B), 30 (F).

The *Trocadero* Group consists of lettuces believed to be selected from Trocadero—a tinted lettuce—the selections being untinted. The symptoms throughout the group are paleness, the heart leaves being crinkled, the lettuce flattened and the heart undeveloped. Stunting may be divided into two classes:—

(a) not marked, Nos. 1—7. (b) marked, Nos. 8, 9.

TABLE I—continued.

Group No.	Variety of Lettuce.	Symptoms.	Incidence in Trials. (per cent. infection).
4.	<i>Lee's Immense Types.</i>		
	Lee's Immense	Plants small, pale and slightly mottled. Hearting somewhat poor.	54 (A), 54 (A), 36 (B), 50 (B), 26 (C), 15 (E), 38 (F).
	Hardy Green Winter ..	do.	36 (A), 78 (B).
	Clarke's Imperial ..	Very slight paling and plants somewhat small. Difficult to detect.	41 (A), 44 (B).
	Exceller	Slight paleness, hearting only slightly reduced in severest cases.	30 (A), 32 (B), 40 (C), 14 (E).
	Hammersmith Hardy ..	Very slight paleness, hearting somewhat reduced.	9 (C), 7 (E).
	Webb's Immense Hardy Green	do.	4 (E).
	Yate's Winter White ..	Much stunted, mottled and pale. Leaves crinkled.	53 (A), 40 (B), 40 (C), 40 (F).
	Schofield's Hardy Winter White	Markedly stunted and mottled. Clearing of veins. Leaves crinkled.	72 (A), 84 (B), 29 (C), 78 (D), 69 (D).

In the *Lee's Immense* Group, the symptoms are not uniform; in Nos. 1—6 mosaic is difficult to detect and does not seriously affect hearting; in Nos. 7 and 8 there is marked stunting and failure to form hearts.

Group No.	Variety of Lettuce.	Symptoms.	Incidence in Trials. (per cent. infection).
5.	<i>Passion Types</i>		
	<i>A. Stanstead Park Types.</i>		
	Stanstead Park	Symptoms not severe; only a slight paling and stunting. Little reduction in hearting.	10 (A), 11 (A), 14 (B), 6 (B), 25 (C), 54 (E).
	Early Spring	Affected plants difficult to detect. Hearting only slightly poorer.	24 (A), 16 (B), 21 (C).
	Tremont Winter	As Stanstead Park.	11 (A), 6 (B).

In the *Stanstead Park* Group the symptoms are uniform in all varieties; the market value of the lettuces is only slightly affected.

TABLE I—continued.

B. <i>Arctic Types.</i>			
Arctic	..	..	..
			Symptoms severe.
			Leaves pale and mottled, much crinkled. Very marked stunting, no hearting.
Arctic King	..	..	Av. diam. healthy plant = 8". Av. diam. mosaic plant = 5".
			22 (A).
			61 (A), 44 (B), 34 (C), 24 (C), 65 (D), 37 (D), 11 (E).
Imperial	..	..	..
			Symptoms very severe, as above. Normal diam. = 9—10". Diam. Mosaic Plant = 6".
			49 (A), 64 (B), 46 (D), 55 (D), 31 (E), 57 (F), 22 (F).
			90 under cloches.
Majestic	..	..	..
			As above. Normal diam. = 10" Mosaic plants = 6".
			48 (A), 80 (B), 16 (C), 78 (D).

In the *Arctic* Group mosaic symptoms are uniform and severe.

6 <i>Mac Hattie's Giant Types.</i>			
MacHattie's Giant	..	..	..
			Much dwarfed. Leaves very crinkled and mottled. No hearting.
			45 (A), 82 (B), 36 (C), 15 (D), 66 (F).
Goliath	..	..	..
			do.
			77 (A), 74 (B).
Whitsuntide	..	..	..
			do.
			58 (A), 56 (B), 33 (C).

In the *Mac Hattie's Giant* Group varieties are badly affected.

7 <i>Iceberg Types.</i>			
Webb's Wonderful	..	..	..
			No heart. Mottled and stunted.

It will be seen from the above table that the symptoms of mosaic are either severe or slight according to the variety. Thus Arctic, one of the most commonly grown winter varieties, is very severely affected, diseased plants being small, pale in colour, and forming no hearts. Such plants are useless for market purposes and become a total loss. On the other hand the variety Stanstead Park and varieties closely related to it are little affected by mosaic. There is only a slight paling, little reduction in hearting, and the diseased plants are marketable. It is obvious that the substitution, for example, of one of the Stanstead Park Group for one of the Arctic Group may obviate much loss.

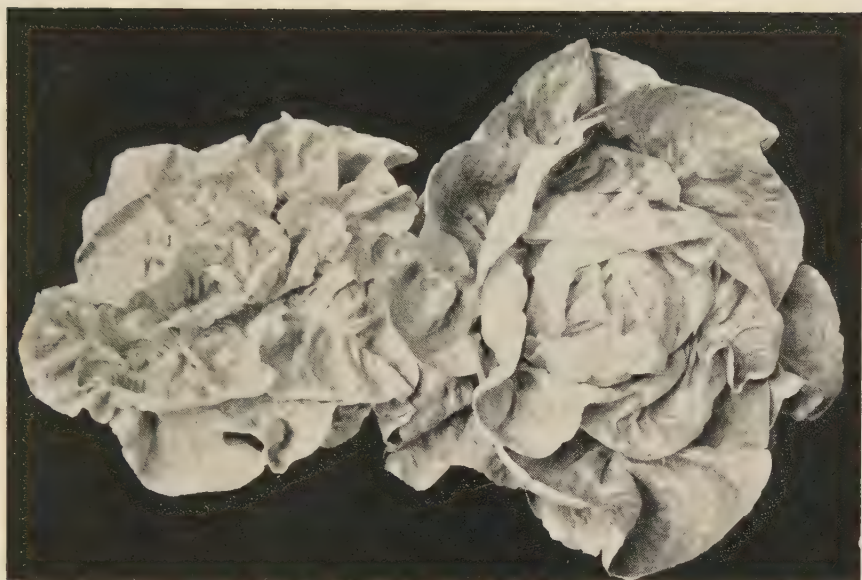


PLATE I. MOSAIC DISEASE OF LETTUCES.
 Variety "Trocadero."
 Left : Infected. Right : Healthy.

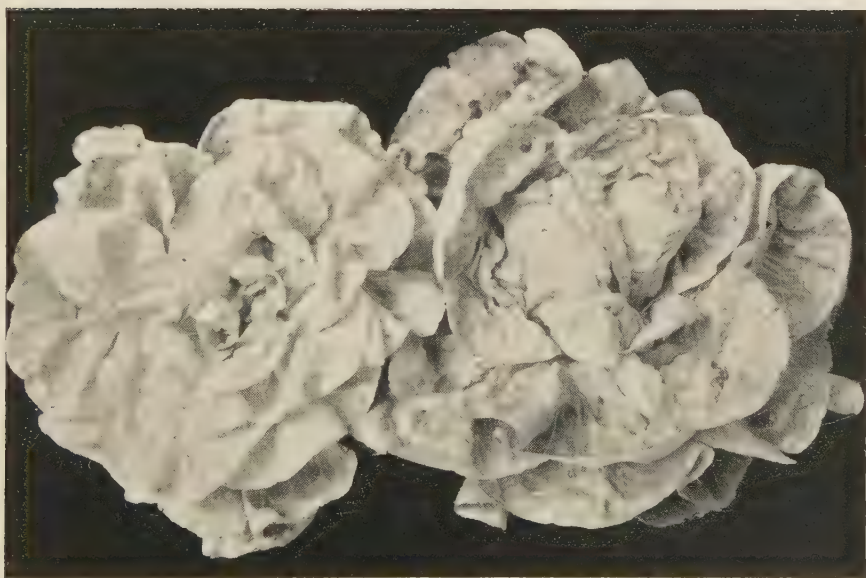


PLATE II. MOSAIC DISEASE OF LETTUCES
 Variety "Stanstead Park."
 Left : Infected. Right : Healthy.

A classification is in progress of all the cabbage lettuce varieties in use in England, and it is hoped that it will be possible to group all these according to their mosaic symptoms.

It is commonly found by growers that later plantings of winter lettuces are less likely to be severely affected with mosaic. This is probably owing to the greater scarcity of aphides as the winter progresses. Thus in one case at Cheltenham an early autumn planting was 66 per cent. infected at maturity, a late autumn planting 35 per cent. infected and a February planting 20 per cent. infected.

DISEASES OF MINT.

Rust (*Puccinia Menthae*).

Hot Water Treatments. It will be recollected that, in previous years, various treatments have been experimented with in the attempt to reduce oecidial infection in forced mint. Watering the plants, prior to lifting the runners, with a $7\frac{1}{2}$ per cent. tar oil emulsion, resulted in a considerable reduction of rust infection, but there appeared to be some risk of injury to the buds, and consequently of a reduced crop.

In the winter of 1934-1935 trials were made of a hot water treatment, the results of which have already been published in the "Gardeners' Chronicle."*

The runners, after lifting, were washed thoroughly with a hose, and immersed for ten minutes in a bath of water heated by gas jets to maintain a temperature of 112°F . In practice it was found necessary to heat the water to 115°F . The introduction of the runners reduced the temperature to 112°F .; the gas jets were then extinguished and the temperature remained sufficiently constant for ten minutes.

The following tables show the results from this treatment at two different times and with two forms of the mint, *Mentha villosa-nervata* Fraser, which is most commonly grown for forcing. The beds of treated and untreated runners were equal in size, and were made from approximately equal amounts of runners.

* Ogilvie, L. and Brian, P. W. "A Hot Water Treatment for Mint Rust." *Gard. Chron.*, Vol. 98, p. 65, July 27, 1935.

TABLE II.
MINT TRIAL NO. 1.

Runners taken up and treated November 10th, 1934, stored under the greenhouse bench, and planted on December 4th, 1934.

<i>Type of Mint.</i>	<i>Treatment.</i>	<i>Total No. of Rusted Shoots.</i>	<i>Total No. of Bunches picked.</i>
Pale ..	Control (no treatment)	63	59
„ ..	Runners washed	36	61
„ ..	Runners washed and hot water treated	0	107
Dark ..	Control (no treatment)	61	37
„ ..	Runners washed	47	38
„ ..	Runners washed and hot water treated	0	61

TABLE III.
MINT TRIAL NO. 2.

Runners taken up and treated January 15th, 1935, and planted immediately.

<i>Type of Mint.</i>	<i>Treatment.</i>	<i>Total No. of Rusted Shoots.</i>	<i>Total No. of Bunches picked.</i>
Pale ..	Control	122	191
„ ..	Runners washed	105	212
„ ..	Runners washed and hot water treated	0	330
Dark ..	Control	134	193
„ ..	Runners washed	109	181
„ ..	Runners washed and hot water treated	0	263

From these tables it will be seen that washing the runners with cold water prior to planting usually reduces the amount of rust slightly. The hot water treatment at 112°F., however, controls the rust completely and results in a very much increased crop of clean mint.

A series of pot trials were carried out in the autumn of 1935 to determine the range of temperatures effective in controlling the rust.

Two types of *M. villosa-nervata* were used and the treatments carried out on December 2nd, 1935, in the same manner as previously.

TABLE IV.
POT TRIALS WITH MINT.

<i>Treatment.</i>	<i>Type of Mint.</i>	<i>No. of Rusted Shoots per 10" pot.</i>
1. Untreated	Pale	14, 11.
do.	Cheltenham Form ..	8, 13, 7, 11.
2. Washed and treated at 115°F. for ten minutes	Pale	0, 0.
do.	Cheltenham Form ..	0, 0, 0, 0.
3. Washed and treated at 110°F. for ten minutes	Pale	0, 0.
do.	Cheltenham Form ..	0, 0, 0, 0.
4. Washed and treated at 105°F. for ten minutes	Pale	0, 0, 0, 0, 0, 0.
do.	Cheltenham Form ..	0, 0, 0, 0.

It will be seen that temperatures of 105°, 110° and 115°F for ten minutes are all equally effective in controlling rust.

In none of these cases was there any reduction in number of shoots following the treatment.

Effect of Temperature. The fact that very little rust usually appeared where growers used high forcing temperatures suggested that such temperatures might cause the mint to grow away from the rust mycelium. As a test a pot of runners of the dark form of *M. villosa-nervata* was forced rapidly by placing it on the top of a hot water pipe in the greenhouse, but 24 severely rusted shoots were produced.

Mode of Infection of Runners. A number of experiments were carried out in the endeavour to infect runners which had been previously hot water treated. Teleutospores were applied to runners in pots at various dates by watering on, by direct transference to the buds by means of a brush and by covering the runners with soil from outside beds, but no oecidial infection resulted.

CIDER MAKING TRIALS FOR THE SEASON 1934-35.

By P. T. H. PICKFORD.

The 1934 cider apple crop was the heaviest recorded for many years in spite of the heavy crop in many districts in the previous year.

The average specific gravity of all the juices examined at Long Ashton was 1.0544. This is a rather high average compared with that of many previous years, although nearly six points lower than the abnormally high figure of 1933.

The quality of the ciders was above average. Although they did not reach the high standard of richness attained in the previous year, in general they were pleasing in flavour and possessed more individual character.

Competitions were arranged on similar lines to those of previous years and in addition several other varieties were tried apart from those entered in the competitions.

Non-Competitive Ciders.

English Varieties.

Three English varieties, Eggleton Styre, Lorna Doone and Sweet Coppin, were tested for vintage quality.

Of these, Lorna Doone, a local variety from Wellington, Somerset, reputed to be an exceptionally heavy cropper, was especially interesting. The cider had a very coarse tannin flavour which left an unpleasant after-taste, and there was a distinctly yeasty flavour which could probably be attributed to the considerable secondary fermentation which had taken place in bottle. Only by blending this with a larger proportion of a good medium sharp type were the defects adjusted. Judging by this season's trial the variety cannot be ranked as of high vintage quality; but as it is of special interest because of its heaving cropping qualities and high tannin content further trials will be made, when possible.

Jersey Varieties.

Three varieties of apples were sent from Jersey (C.I.), Variety No. I, "Petit Jean" and "Frequin." The first mentioned variety belonged to the sweet class and the two latter sorts were medium sharps. All three ciders were very pleasant and fruity in flavour but lacked astringency.

Irish Varieties.

Four varieties, Kemp, Royal Codlin, Keegan's Crab and White Dutch were received from Northern Ireland. They were all of the culinary type, and made ciders thin in flavour and lacking body. White Dutch, however, produced a particularly clean, sharp cider which would be valuable for blending with bittersweet juice.

The Cider Competitions.

For the tenth year in succession, competitions were arranged on similar lines to those described in previous reports with two modifications, the bittersweet varieties being divided into two classes according to their normal tannin content and a class for pears re-introduced.

113 entries of fruit were received, of which 103 were apples and 10 pears. The competitions were open to growers residing in the usual counties, and the entries from the different counties were distributed as follows:—Devon, 26; Dorset, 1; Gloucester, 14; Herefordshire, 7; Monmouthshire, 18; Somerset, 40; Worcester-shire, 7.

The ciders were judged on April 16th, 1935, by Messrs. L. V. Bickford (Messrs. Jno. Symons & Co., Ltd.), Totnes, Devon; P. W. D. Izzard, The Pleasaunce, Roydon, Essex; H. J. Phelps, Tibberton, Gloucester, and the perries on the same date by Mr. Stafford Weston, Much Marcle, Hereford. They reported as follows:—

"The judging of the ciders and perries in these Competitions took place on April 16th, 1935.

Although the ciders on the whole did not reach the exceptional richness of those of last year, yet the quality was above average. In general, they were more pleasing in flavour than last year's ciders, having more individual character and aroma. The perries, however, were fair in quality.

Class 1, for Kingston Black, comprised only 4 entries. The first two awards stood out above the others, and were considered to be very pleasant ciders with aroma distinctly more marked than in the previous year's samples.

Class 2A, for ciders of high acidity, attracted 17 entries. They were very good on the whole, having considerably more individual character than is usual with sharp varieties. A particularly clean acid character was noticeable in nearly every case and their blending quality throughout was useful.

Class 2B, for varieties of medium acidity, was a particularly strong class. All these were pleasant ciders and more than half of them reached a very high standard. The even quality of many in this class made the placing of the awards very difficult. It was interesting to find that a large proportion were so well balanced in their qualities as to make a good drink unblended. There were 31 entries in this class.

Class 3, with 27 entries of sweet varieties, was another strong class which proved difficult to judge. It was a splendid class as a whole, the ciders being more even than in any other class. The lack of aroma was a noticeable feature of this class.

Class 4A, was for mild bittersweet varieties, and had 10 entries. This was a very good and level class and justified the segregation of mild bittersweet varieties in a category of their own.

Class 4B, was composed of 14 bittersweet varieties of which normally the tannin content is above 0.3 per cent. This was also considered a very good class in which were several excellent bittersweets. Here the first two awards were outstanding, both being excellent ciders.

Class 5, for perries, received 10 entries. On the whole the quality was only fair, but it was felt that several of the samples would show great improvement after further maturity. There was no entry of outstanding merit, but by judicious blending a perry of satisfactory quality was obtainable in several instances.

In view of the evenness of the first two ciders in *Class 1*, it was recommended that a second prize should be given in spite of the small number of entries. The same position arose in *Class 4A*, where it was recommended that a third prize should be given. It was also decided to recommend a third prize in *Class 5*.

Special mention should be made of the assistance given by the

specimen blends made at the Institute for each entry in the sharp class. These blends proved helpful in the decision of several of the awards.

The division of the bittersweet varieties into two classes was very much appreciated, and made the judging of the bittersweet varieties much more satisfactory.

In conclusion, we should like to express our appreciation of the impartial manner in which all the samples were prepared and displayed before us. The uniform treatment of the juices and the complete absence of taints throughout reflects great credit on those responsible for the work."

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 16/35).	Notes on Ciders.
CLASS 1.—KINGSTON BLACK ONLY.				
No. 1. (Upton Snodsbury, Worcs.)	1.080 (26/11/34)	M. 0.66 T. 0.20 F. 5.3	(a) 1.030 (26/2/35) (b) 1.030 (16/4/35)	Rich and full flavoured, but spoilt by an unpleasant bitter character.
No. 2. (Bushley, Worcs.)	1.073 (26/11/34)	M. 0.67 T. 0.20 F. 4.5	(a) 1.030 (15/2/35) (b) 1.028 (16/4/35)	Less heavy in flavour than the pre- vious cider, but very pleasant and cleaner on the palate.
No. 3. (Curry Rivel, Som.)	1.072 (26/11/34)	M. 0.61 T. 0.18 F. 4.5	(a) 1.030 (15/2/35) (b) 1.029 (16/4/35)	Very good quality full and pleasant in flavour with a pleasant aroma.
No. 4. (Ross, Hereford)	1.071 (26/11/34)	M. 0.68 T. 0.20 F. 6.5	(a) 1.030 (3/1/35) (b) 1.028 (16/4/35)	A more acid cider of fair quality.
SHARP VARIETIES.—Acidity normally above 0.45 per cent. Malic Acid.				
(CLASS 2A.—SHARP. Acidity normally not less than 0.75 per cent.				
Aswell Redstripe. (Ilminster, Som.)	1.043 (28/11/34)	M. 0.79 T. 0.12 F. 7.5	(a) 1.030 (4/12/34) (b) 1.027 (16/4/35)	Rather poor quality lacking in character.
Beeche's Green. (Dymock, Glos.)	1.056 (6/12/34)	M. 1.04 T. 0.26 F. 6.5	(a) 1.030 (20/12/34) (b) 1.029 (16/4/35)	Very harsh in flavour; the acid and tannin characters were too pro- nounced.
Broadtails. (Shrawley, Worcs.)	1.061 (28/11/34)	M. 0.89 T. 0.13	(a) 1.030 (12/12/34) (b) 1.027 (16/4/35)	Fair quality.

COMPETITIVE VARIETIES.

SHARP VARIETIES—continued.

Cap of Liberty. (Shepton Mallet, Som.)	1.054 (28/11/34)	M. T. F.	0.82 0.17 4.5	(a) 1.030 (13/12/34) (b) 1.028 (16/4/35)	A very good sharp cider, fresh and clean in flavour with a pleasant astringency.
Cowdsen Bromley. (Upton Snodsbury, Wores.)	1.063 (19/11/34)	M. T.	0.92 0.23	(a) 1.030 (17/12/34) (b) 1.028 (16/4/35)	An outstandingly good cider, although the tannin character was rather hard.
Dorsets. (Shapwick, Som.)	1.053 (20/11/34)	M. T.	0.76 0.23	(a) 1.030 (26/12/34) (b) 1.029 (16/4/35)	Rather poor quality, with a coarse tannin character.
Fair Maid of Devon. (Newton St. Cyres, Devon)	1.043 (22/10/34)	F. M. T.	3.7 0.75 0.10	(a) 1.030 (30/10/34) (b) 1.026 (16/4/35)	Thin in quality and lacking freshness of flavour.
Frederick. (Monmouth, Mon.)	1.056 (22/10/34)	F. M. T.	8.5 0.97 0.10	(a) 1.030 (23/11/34) (b) 1.028 (16/4/35)	Clean sharp cider of fair quality.
Frederick. (Usk, Mon.)	1.055 (23/10/34)	F. M.	6.0 0.92	(a) 1.030 (30/11/34) (b) 1.027 (16/4/35)	Very good sharp cider: fuller in flavour than the previous sample and with a pleasant smooth acidity.
Frederick. (Abergavenny, Mon.)	1.048 (23/10/34)	F. M. T.	6.0 0.90 0.09	(a) 1.030 (26/11/34) (b) 1.028 (16/4/35)	Good quality, with a clean pleasing acid character.
Frederick. (Rockfield, Mon.)	1.056 (6/11/34)	F. M. T.	6.5 0.96 0.06	(a) 1.030 (28/11/34) (b) 1.029 (16/4/35)	High quality juice, but the cider lacked the pleasant freshness usually attributed to this variety.
Frederick. (Raglan, Mon.)	1.055 (6/11/34)	F. M. T.	7.7 0.83 0.07	(a) 1.030 (7/12/34) (b) 1.028 (16/4/35)	A fairly good sound sharp, but lacking in fullness of flavour.
Gloucestershire Kernel. (Rockfield, Mon.)	1.050 (29/10/34)	F. M. T.	4.6 0.91 0.14	(a) 1.030 (23/11/34) (b) 1.028 (16/4/35)	A poor quality cider.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at Time of Filtering. (a) Date of Judging. (b) (April 16/35).	Notes on Ciders.
CLASS 2A.—SHARP— <i>continued</i> .				
Late Norman (Rockfield, Mon.)	1.050 (19/11/34)	M. 0.75 T. 0.08 F. 7.5	(a) 1.030 (4/12/34) (b) 1.027 (16/4/35)	A cider of very little character, but quite clean in flavour.
Redstripe. (Ilminster, Som.)	1.054 (29/10/34)	M. 0.85 T. 0.17 F. 6.7	(a) 1.030 (28/11/34) (b) 1.026 (16/4/35)	Only fair in quality, lacked character and had a poor aftertaste.
Rockfield Cowarne. (Rockfield, Mon.)	1.059 (6/11/34)	M. 0.78 T. 0.14 F. 8.0	(a) 1.030 (19/12/34) (b) 1.028 (16/4/35)	A very good cider, pleasant and full in flavour, with a marked apple character.
White Thorn Pippin. (Stonehouse, Glos.)	1.045 (9/10/34)	M. 0.81 T. 0.11 F. 13.0	(a) 1.030 (16/10/34) (b) 1.023 (16/4/35)	A clean sharp cider but the acidity hard and the flavour rather watery.
CLASS 2B.—MEDIUM SHARP. Acidity normally between 0.45 and 0.75 per cent.				
Badens. (Cheddar, Som.)	1.046 (10/12/34)	M. 0.48 T. 0.11 F. 10.0	(a) 1.030 (17/12/34) (b) 1.018 (16/4/35)	Very poor quality cider; thin and watery in flavour.
Coleman. (Pinhoe, Devon)	1.050 (21/11/34)	M. 0.44 T. 0.13 F. 4.0	(a) 1.030 (15/12/34) (b) 1.029 (16/4/35)	A pleasant cider with a particularly soft apple flavour.
Coleman's Seedling. (Newton St. Cyres, Devon)	1.054 (29/10/34)	M. 0.71 T. 0.16 F. 4.5	(a) 1.030 (11/12/34) (b) 1.028 (16/4/35)	Pleasant cider of fair quality but rather too sharp for this class.
Cowdsen Green. (Upton Snodsbury, Wores.)	1.058 (27/11/34)	M. 0.57 T. 0.10 F. 16.0	(a) 1.030 (4/12/34) (b) 1.027 (16/4/35)	Quite a pleasant juice but not outstanding in quality.

COMPETITIVE VARIETIES.

CLASS 2B.—MEDIUM SHARP— <i>continued</i> .						
Crimson King. (Honiton, Devon)	1.058 (1/11/34)	M. T.	0.64 0.13	(a) 1.030 (23/11/34) (b) 1.024 (16/4/35)	A good clean, sharp cider.	
Crimson King. (Kittisford, Som.)	1.066 (1/11/34)	F. M. T.	8.7 0.79 0.13	(a) 1.030 (1/12/34) (b) 1.029 (1/4/35)	Rather high in acidity but pleasant in flavour and smooth on the palate.	
Crimson King. (Newton St. Cyres, Devon)	1.056 (1/11/34)	F. M. T.	7.7 0.50 0.13	(a) 1.030 (29/11/34) (b) 1.029 (16/4/35)	A good medium-sharp cider with a very soft flavour.	
Crimson King. (Taunton, Som.)	1.058 (12/11/34)	F. M. T.	6.0 0.55 0.11	(a) 1.030 (4/12/34) (b) 1.026 (16/4/35)	A pleasant clean sharp cider with a pronounced apple character.	
Crimson Norman. (Dymock, Glos.)	1.058 (4/12/34)	F. M. T.	6.7 0.58 0.29	(a) 1.030 (17/1/35) (b) 1.028 (16/4/35)	A very full rich medium-sharp cider.	
Dymock Red. (Dymock, Glos.)	1.068 (12/11/34)	F. M. T.	3.8 0.51 0.26	(a) 1.030 (17/12/34) (b) 1.027 (16/4/35)	A fine quality cider although a little too high in tannin flavour for use unblended.	
Fair Maid of Taunton. (Shaftesbury, Som.)	1.054 (20/11/34)	F. M. T.	7.5 0.66 0.16	(a) 1.030 (15/12/34) (b) 1.028 (16/4/35)	Only fair in quality.	
Greasy Pippin. (Taunton, Som.)	1.052 (28/11/34)	F. M. T.	6.0 0.68 0.16	(a) 1.030 (12/12/34) (b) 1.025 (16/4/35)	Not outstanding in quality: lacking character.	
Hollow Core. (Crediton, Devon)	1.053 (21/11/34)	F. M. T.	5.0 0.62 0.15	(a) 1.030 (24/12/34) (b) 1.028 (16/4/35)	Fair quality with a pleasant clean flavour but rather thin.	
Knot Oak Sharp. (Ilminster, Som.)	1.051 (1/11/34)	F. M. T.	3.8 0.55 0.08	(a) 1.030 (22/11/34) (b) 1.026 (16/4/35)	A rather poor quality cider.	

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) % Tannin (T) % and Rate of Fermentation (F).	Gravity at Time of Filtering. Date of Judging. (April 16/35).	Notes on Ciders.
CLASS 2B.—MEDIUM SHARP— <i>continued.</i>				
Langworthy. (Newton St. Cyres, Devon)	1.050 (29/10/34)	M. 0.49 T. 0.14 F. 4.7	(a) 1.030 (7/12/34) (b) 1.028 (16/4/35)	A good cider with a distinct apple flavour, making a pleasant drink unblended.
Langworthy. (Newton St. Cyres, Devon)	1.051 (19/11/34)	M. 0.50 T. 0.12 F. 2.7	(a) 1.030 (14/1/35) (b) 1.028 (16/4/35)	A typical Langworthy cider with a very pleasing aroma.
Langworthy. (Credition, Devon)	1.051 (21/11/34)	M. 0.44 T. 0.16 F. 3.4	(a) 1.030 (11/1/35) (b) 1.028 (16/4/35)	A good medium sharp cider.
Langworthy. (Newton St. Cyres, Devon)	1.047 (3/12/34)	M. 0.43 T. 0.12 F. 4.4	(a) 1.030 (10/12/34) (b) 1.028 (16/4/35)	A typical Langworthy cider with a very pleasant soft acidity.
Monmouth Red. (Rockfield, Mon.)	1.047 (4/12/34)	M. 0.53 T. 0.12 F. 4.3	(a) 1.030 (28/12/34) (b) 1.028 (16/4/35)	Only fair in quality, lacking fullness of flavour.
Neverlight. (Shapwick, Som.)	1.057 (20/11/34)	M. 0.62 T. 0.18 F. 6.0	(a) 1.030 (17/12/34) (b) 1.028 (16/4/35)	A pleasant cider, but not outstanding in quality.
Peggies. (Bushley, Wores.)	1.066 (12/11/34)	M. 0.60 T. 0.18 F. 4.7	(a) 1.030 (17/1/35) (b) 1.028 (16/4/35)	A very good cider rich with a smooth pleasing flavour.
Prices Kernel. (Bushley, Wores.)	1.046 (6/12/34)	M. 0.51 T. 0.19 F. 4.0	(a) 1.030 (13/12/34) (b) 1.028 (16/4/35)	A fair quality cider, but the tannin character too pronounced.

COMPETITIVE VARIETIES.

CLASS 2B.—MEDIUM SHARP—*continued*.

Red Foxwhelp. (Byford, Hereford)	1.050 (29/10/34)	M. 0.59 T. 0.22 F. 5.7	(a) 1.030 (24/11/34) (b) 1.027 (16/4/35)	A good clean, sharp cider with a pleasant apple flavour and aroma.
Royal Weldon. (Stonehouse, Glos.)	1.052 (22/10/4)	M. 0.51 T. 0.19 F. 6.0	(a) 1.030 (15/11/34) (b) 1.022 (16/4/35)	Only fair in quality, lacking character.
Small Redstripe. (Ilminster, Som.)	1.050 (10/12/34)	M. 0.44 T. 0.15 F. 5.0	(a) 1.030 (26/12/34) (b) 1.028 (16/4/35)	A pleasant cider, soft but not very full in flavour.
Styre. (Rockfield, Mon.)	1.050 (1/11/34)	M. 0.46 T. 0.06 F. 6.7	(a) 1.030 (22/11/34) (b) 1.026 (16/4/35)	Quite a pleasant light cider, but rather watery in flavour.
Teign Harvey. (Pinhoe, Devon)	1.044 (4/12/34)	M. 0.58 T. 0.17 F. 2.0	(a) 1.030 (12/1/35) (b) 1.029 (16/4/35)	A very good cider with a clean fresh apple flavour.
Tom Putt (Bag Apple). (Stonehouse, Glos.)	1.052 (9/10/34)	M. 0.74 T. 0.12 F. 14.0	(a) 1.030 (16/10/34) (b) 1.019 (16/4/35)	A poor, thin cider.
Toogood Bitter. (Cheddar, Som.)	1.054 (3/12/34)	M. 0.52 T. 0.20 F. 7.7	(a) 1.030 (12/12/34) (b) 1.027 (16/4/35)	A good cider, but too high in tannin flavour unblended.
White Pippin. (Usk, Mon.)	1.042 (4/12/34)	M. 0.49 T. 0.12 F. 4.0	(a) 1.030 (19/12/34) (b) 1.026 (16/4/35)	A rather thin cider lacking character.
White Sheep's Nose. (Honiton, Devon)	1.048 (19/11/34)	M. 0.62 T. 0.19 F. 7.6	(a) 1.030 (4/12/34) (b) 1.027 (16/4/35)	A poor quality cider, coarse in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) % ¹⁰⁰ , and Rate of Fermentation (F).	Gravity at (a) Time of Filtering, (b) Date of Judging. (April 16/35).	Notes on Ciders.
CLASS 3.—SWEET VARIETIES. Acidity normally below 0.45 per cent., and tannin below 0.20 per cent.				
Broom Apple. (Raglan, Mon.)	1.055 (6/11/34)	M. 0.29 T. 0.17 F. 5.2	(a) 1.025 (22/12/34) (b) 1.023 (16/4/35)	Quite a pleasant cider, but not out- standing.
Cadbury. (North Cadbury, Som.)	1.047 (28/11/34)	M. 0.40 T. 0.19 F. 4.5	(a) 1.025 (12/12/34) (b) 1.022 (16/4/35)	Only fair in quality and rather insipid.
Green Striped. (Taunton, Som.)	1.061 (3/12/34)	M. 0.21 T. 0.17 F. 6.8	(a) 1.025 (20/12/34) (b) 1.022 (16/4/35)	A full flavoured cider, but the tannin character coarse.
Hangdown. (Shapwick, Som.)	1.057 (20/11/34)	M. 0.32 T. 0.18 F. 3.6	(a) 1.025 (9/1/35) (b) 1.023 (16/4/35)	A very pleasant cider, soft in flavour with a good aroma.
Horners (Hangdown). (Ilminster, Som.)	1.048 (6/12/34)	M. 0.38 T. 0.14 F. 4.5	(a) 1.025 (19/12/34) (b) 1.023 (16/4/35)	Fair in quality, a little too acid for this class.
Prescoed. (Usk, Mon.)	1.050 (4/12/34)	M. 0.30 T. 0.17 F. 5.0	(a) 1.025 (29/12/34) (b) 1.024 (16/4/35)	Not of outstanding quality, but quite a useful cider.
Rockfield Cummy. (Rockfield, Mon.)	1.051 (6/11/34)	M. 0.21 T. 0.15 F. 5.3	(a) 1.025 (12/12/34) (b) 1.022 (16/4/35)	A pleasant cider of fair quality.
Scott's Sweet. (Ilminster, Som.)	1.044 (10/12/34)	M. 0.30 T. 0.14 F. 5.7	(a) 1.025 (22/12/34) (b) 1.024 (16/4/35)	Rather poor in quality.

COMPETITIVE VARIETIES.

CLASS 3.—SWEET VARIETIES—continued.

Slack-ma-Girdle. (Shapwick, Som.)	1.056 (20/11/34)	M. 0.26 T. 0.14 F. 6.5	(a) 1.025 (15/12/34) (b) 1.024 (16/4/35)	A fairly good cider.
Slack-ma-Girdle. (Crediton, Devon)	1.050 (6/12/34)	M. 0.27 T. 0.12 F. 5.2	(a) 1.025 (19/12/34) (b) 1.023 (16/4/35)	Poor quality: not up to the usual standard of this variety.
Slack-ma-Girdle. (Honiton, Devon)	1.058 (6/12/34)	M. 0.29 T. 0.15 F. 3.6	(a) 1.025 (18.2.35) (b) 1.023 (16.4/35)	A full bodied cider, but not clean in flavour.
Sowton Sweet. (Honiton, Devon)	1.049 (19.11/34)	M. 0.38 T. 0.18 F. 4.3	(a) 1.025 (12/12/34) (b) 1.023 (16/4/35)	A pleasant cider, but lacking character.
Sugar Sweet. (Shapwick, Som.)	1.052 (20/11/34)	M. 0.28 T. 0.08 F. 4.8	(a) 1.025 (26/12/34) (b) 1.023 (16/4/35)	A pleasant neutral flavoured cider, but possessing little character.
Sweet Alford. (Woodbury, Devon)	1.033 (1/11/34)	M. 0.20 T. 0.15 F. 4.0	(a) 1.025 (27/12/34) (b) 1.024 (16.4.35)	A pleasant, soft, neutral sweet cider with a good apple aroma.
Sweet Alford. (Newton St. Cyres, Devon)	1.064 (1/11/34)	M. 0.20 T. 0.17 F. 3.2	(a) 1.025 (19/2/35) (b) 1.023 (16/4/35)	A good rich cider having a little more character than the previous sample.
Sweet Alford. (Crediton, Devon)	1.052 (3/12/34)	M. 0.24 T. 0.15 F. 4.0	(a) 1.025 (22/12/34) (b) 1.024 (16/4/35)	A very pleasant soft cider with a good aroma.
Sweet Blenheim. (Newton St. Cyres, Devon)	1.050 (22/10/34)	M. 0.33 T. 0.12 F. 7.5	(a) 1.025 (14/11/34) (b) 1.020 (16/4/35)	A poor cider of uninteresting flavour.
Sweet Blenheim. (Taunton, Som.)	1.052 (12/11/34)	M. 0.23 T. 0.10 F. 8.0	(a) 1.025 (1/12/34) (b) 1.022 (16/4/35)	A poor quality cider.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %/ and Rate of Fermentation (F).	(Gravity at Time of Filtering. Date of Judging. (April 16/35).		Notes on Ciders.
			(a)	(b)	
CLASS 3.—SWEET VARIETIES—continued.					
Sweet Cluster. (Pinhoe, Devon)	1.047 (3/12/34)	M. T. F. 0.18 0.15 4.2	(a) 1.025 (27/12/34) (b) 1.024 (16/4/35)		A thin-flavoured cider, lacking character.
Sweet Coppin. (Pinhoe, Devon)	1.045 (3/12/34)	M. T. F. 0.19 0.13 2.5	(a) 1.025 (22/1/35) (b) 1.024 (16/4/33)		A soft, pleasant cider with a marked apple flavour and aroma.
Sweet Jersey. (Ilminster, Som.)	1.045 (10/12/34)	M. T. F. 0.29 0.15 7.0	(a) 1.025 (18/12/34) (b) 1.022 (16/4/35)		Not a pleasant cider; poor quality.
Sweet Woodbine. (Newton St. Cyres, Devon)	1.050 (25/10/34)	M. T. F. 0.30 0.15 4.2	(a) 1.025 (8/12/34) (b) 1.024 (16/4/35)		A poor sample, far below standard.
Truckle Apple. (Ilminster, Som.)	1.049 (28/11/34)	M. T. F. 0.32 0.12 9.5	(a) 1.025 (6/12/34) (b) 1.022 (16/4/35)		Only fair in quality, not having much character.
Woodbine. (Shapwick, Som.)	1.053 (20/11/34)	M. T. F. 0.28 0.13 6.0	(a) 1.025 (15/12/34) (b) 1.024 (16/4/35)		Of fair quality.
Woodbine. (Netherbury, Dorset)	1.050 (6/12/34)	M. T. F. 0.32 0.12 8.0	(a) 1.025 (15/12/34) (b) 1.023 (16/4/35)		Quite a good sweet cider, but not very full in flavour.
Woodbine. (Ilminster, Som.)	1.055 (6/12/34)	M. T. F. 0.29 0.13 4.6	(a) 1.025 (11/1/35) (b) 1.025 (16/4/35)		A very good, full-flavoured sweet cider.
Woodbine. (Ilminster, Som.)	1.054 (6/12/34)	M. T. F. 0.25 0.13 4.6	(a) 1.025 (23/1/35) (b) 1.025 (16/4/35)		A good cider, but not so clean in flavour as previous sample.

COMPETITIVE VARIETIES.

BITTERSWEET VARIETIES. Acidity normally below 0.45 per cent., and tannin above 0.2 per cent.			
CLASS 4A.—MILD BITTERSWEETS.			
Cummy Norman. (Norton Canon, Hereford)	Normally tannin below 0.3 per cent.		A fairly good bitter, but spoilt by a soapy flavour.
	M. 1.058	(a) 1.025 (8/12/34)	
	T. 0.21	(b) 1.019 (16/4/35)	
George James. (North Cadbury, Som.)			A very good soft, mild, bittersweet, having a very pleasant tannin flavour.
	M. 0.25	(a) 1.025 (7/12/34)	
	T. 0.23	(b) 1.022 (16/4/35)	
Monkerton Bitter. (Pinhoe, Devon)			A rich cider with a particularly smooth tannin character.
	M. 0.24	(a) 1.025 (23/1/35)	
	T. 0.20	(b) 1.024 (16/4/35)	
Perthyre. (Tregare, Mon.)			A fair cider, but not very clean on the palate.
	M. 0.28	(a) 1.025 (15.11/34)	
	T. 0.20	(b) 1.020 (16/4/35)	
Perthyre. (Monmouth, Mon.)			Not very good; rather hard in flavour.
	M. 0.35	(a) 1.025 (16/11/34)	
	T. 0.20	(b) 1.020 (16/4/35)	
Perthyre. (Rockfield, Mon.)			Of very much better quality than the two previous samples, and fuller in flavour.
	M. 0.32	(a) 1.025 (15/12/34)	
	T. 0.14	(b) 1.022 (16/4/35)	
River Apple A. (Axbridge, Som.)			A cider of poor character, thin and dry in flavour.
	M. 0.33	(a) 1.025 (6/11/34)	
	T. 0.22	(b) 1.018 (16/4/35)	
Spotted Dick. (Woodbury, Devon)			Fair in quality; quite a full-flavoured bittersweet.
	M. 0.36	(a) 1.025 (24/12/34)	
	T. 0.21	(b) 1.024 (16/4/35)	
Stoke White Norman. (Rodney Stoke, Som.)			A pleasant mild bitter cider, but not very full in flavour.
	M. 0.16	(a) 1.025 (29/10/34)	
	T. 0.21	(b) 1.020 (16/4/35)	
Yellow Bittersweet. (Taunton, Som.)			A fairly good cider, but with a rather hard bitter character.
	M. 0.25	(a) 1.025 (10/12/34)	
	T. 0.25	(b) 1.021 (16/4/35)	

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering, (b) Date of Judging. (April 16/35).	Notes on Ciders.
CLASS 4B.—BITTERSWEET. Normally tannin above 0.30 per cent.				
Bitter Jersey. (Ilminster, Som.)	1.057 (21/11/34)	M. 0.34 T. 0.36 F. 4.5	(a) 1.025 (5/1/35) (b) 1.025 (16/4/35)	Fair in quality, but the tannin flavour rather unpleasant.
Bitter Jersey. (Ilminster, Som.)	1.048 (6/12/34)	M. 0.30 T. 0.27 F. 6.0	(a) 1.025 (14/12/34) (b) 1.022 (16/4/35)	Similar to the previous sample, but with a coarser tannin flavour.
Denning's Alford. (Ilminster, Som.)	1.053 (21/11/34)	M. 0.30 T. 0.26 F. 8.7	(a) 1.025 (10/12/34) (b) 1.021 (16/4/35)	A rather poor cider without character
Harry Masters' Jersey. (North Cadbury, Som.)	1.058 (3/12/34)	M. 0.19 T. 0.28 F. 4.2	(a) 1.025 (2/2/35) (b) 1.023 (16/4/35)	A very good cider, but hardly any tannin flavour.
Jennings' Bitter. (Shapwick, Som.)	1.055 (20/11/34)	M. 0.28 T. 0.26 F. 6.7	(a) 1.025 (17/12/34) (b) 1.023 (16/4/35)	A good cider; mild bittersweet in flavour.
Knotted Kernel. (Norton Canon, Hereford)	1.061 (12/11/34)	M. 0.26 T. 0.29 F. 8.0	(a) 1.025 (12/12/34) (b) 1.022 (16/4/35)	A rich smooth, bittersweet cider; full in flavour.
Knotted Kernel. (Byford, Hereford)	1.067 (12/11/34)	M. 0.26 T. 0.33 F. 7.2	(a) 1.025 (29/12/34) (b) 1.024 (16/4/35)	An excellent cider with a pleasant smooth tannin character.
Rattlebasket. (Woodbury, Devon)	1.053 (1/11/34)	M. 0.35 T. 0.30 F. 4.2	(a) 1.025 (19/12/34) (b) 1.023 (16/4/35)	Rather poor quality; thin in flavour.
River Apple B. (Cheddar, Som.)	1.060 (22/10/34)	M. 0.24 T. 0.42 F. 9.5	(a) 1.025 (16/11/34) (b) 1.021 (16/4/35)	A very good cider, although tannin flavour inclined to be harsh.

COMPETITIVE VARIETIES.

CLASS 4B.—BITTERSWEET—*continued*.

Royal Jersey. (North Cadbury, Som.)	1.063 (3/12/34)	M. 0.20 T. 0.28 F. 5.6	(a) 1.025 (21/1/35) (b) 1.023 (16/4/35)	A very rich bittersweet; almost too heavy in flavour.
Stable Jersey. (Shepton Mallet, Som.)	1.055 (6/12/34)	M. 0.24 T. 0.25 F. 7.6	(a) 1.025 (29/12/34) (b) 1.024 (16/4/35)	A full-flavoured cider, but with a very hard tannin character.
Strawberry Norman. (Rockfield, Mon.)	1.054 (21/11/34)	M. 0.37 T. 0.32 F. 4.0	(a) 1.025 (4/1/35) (b) 1.024 (16/4/35)	Fair in quality, but spoilt by a coarse tannin flavour.
Strawberry Norman. (Newton Abbot, Devon)	1.050 (3/12/34)	M. 0.26 T. 0.27 F. 7.0	(a) 1.025 (17/12/34) (b) 1.024 (16/4/35)	A good flavoured cider, but the tannin character rough.
Yarlington Mill Jersey. (North Cadbury, Som.)	1.052 (3/12/34)	M. 0.18 T. 0.24 F. 4.0	(a) 1.025 (12/1/35) (b) 1.024 (16/4/35)	A pleasant cider, but not very full in flavour.

CLASS 5.—PERRIES.

Blakeney Red. (Dymock, Glos.)	1.060 (9/10/34)	M. 0.42 T. 0.12 F. 6.4	(a) 1.030 (24/11/34) (b) 1.028 (16/4/35)	Quite a pleasant light perry, but not outstanding.
Blakeney Red. (Arlingham, Glos.)	1.051 (11/10/34)	M. 0.48 T. 0.11 F. 3.5	(a) 1.030 (19/12/34) (b) 1.028 (16/4/35)	Pleasant, but very watery in flavour.
Blakeney Red. (Norton Canon, Hereford)	1.044 (26/10/34)	M. 0.45 T. 0.11 F. 10.5	(a) 1.030 (10/11/34) (b) 1.027 (16/4/35)	A poor quality perry without character.
Butt. (Chaceley, Glos.)	1.068 (21/11/34)	M. 0.58 T. 0.34 F. 4.7	(a) 1.030 (15/2/35) (b) 1.029 (16/4/35)	Very astringent and of poor quality.
Butt. (Uckington, Glos.)	1.062 (21/11/34)	M. 0.53 T. 0.27 F. 3.2	(a) 1.030 (16/2/35) (b) 1.029 (16/4/35)	Fairly good-flavoured perry, but not very full.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering, (b) Date of Judging. (April 16/35).	Notes on Ciders.
(CLASS 5.—PERRIES— <i>continued</i> .)				
Huffcap. (Stonehouse, Glos.)	1.066 (15/10/34)	M. 0.69 T. 0.16 F. 9.0	(a) 1.030 (5/12/34) (b) 1.029 (16/4/35)	A good full-bodied perry of pleasant appearance.
Moorcroft. (Newent, Glos.)	1.067 (2/10/34)	M. 0.52 T. 0.14 F. 5.0	(a) 1.030 (23/10/34) (b) 1.027 (16/4/35)	Quite fair in quality, but lacking fullness of flavour.
Oldfield. (Uckington, Glos.)	1.074 (31/10/34)	M. 0.45 T. 0.19 F. 7.8	(a) 1.030 (31/12/34) (b) 1.029 (16/4/35)	A full heavy-flavoured perry, but unattractive.
Oldfield. (Norton, Glos.)	1.066 (31/10/34)	M. 0.69 T. 0.15 F. 3.0	(a) 1.030 (21/2/35) (b) 1.029 (16/4/35)	A very pleasing drink with a good fruity flavour, but rather high in acidity.
Oldfield. (Westhide, Hereford)	1.070 (17/11/34)	M. 0.56 T. 0.18 F. 6.0	(a) 1.030 (18/2/35) (b) 1.027 (16/4/35)	Poor in quality; far below the usual standard of this variety.

NON-COMPETITIVE VARIETIES.

Variety and Grower.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) % and Rate of Fermentation (F).	Gravity at (a) Time of Filtering, (b) Date of Sampling, (April 16/35).	Notes on Ciders.
ENGLISH VARIETIES.				
Eggleton Styre. (W. Wootton, Byford, Hereford).	1.058 (8/11/34)	M. 0.24 T. 0.13 F. 6.2	(a) 1.025 (10/12/34) (b) 1.023 (16/4/35)	A full rich cider soft and pleasant in flavour.
Lorna Doone. (E. H. Wells, Wellington, Som.).	1.061 (15/10/34)	M. 0.46 T. 0.32 F. 9.0	(a) 1.030 (29/10/34) (b) 1.024 (16/4/35)	A strong flavoured cider with a very coarse unpleasant tannin character
Sweet Coppin. (S. B. Neill, Woodbury, Devon).	1.057 (1/11/34)	M. 0.25 T. 0.15 F. 4.3	(a) 1.025 (20/12/34) (b) 1.023 (16/4/35)	A good quality clean cider with a pleasant neutral flavour.
JERSEY VARIETIES.				
No. 1. (C. le Gallais, Jersey, C.I.).	1.054 (15/1/35)	M. 0.21 T. 0.11 F. 7.0	(a) 1.025 (5/2/35) (b) 1.023 (16/4/35)	Pleasant cider with a good apple flavour and aroma.
"Frequin." (C. le Gallais, Jersey, C.I.).	1.050 (15/1/35)	M. 0.52 T. 0.12 F. 6.0	(a) 1.030 (11/2/35) (b) 1.027 (16/4/35)	Pleasant cider with more character than the previous sample.
"Petit Jean." (C. le Gallais, Jersey, C.I.).	1.053 (15/1/35)	M. 0.54 T. 0.10 F. 6.2	(a) 1.025 (5/2/35) (b) 1.021 (16/4/35)	Quite a pleasant light cider, but lacking character
IRISH VARIETIES.				
Keegan's Crab. (Northern Ireland).	1.045 (15/10/34)	M. 0.74 T. 0.11 F. 6.7	(a) 1.030 (22/10/34) (b) 1.024 (16/4/35)	A cider of little character, thin in flavour, with a very penetrating acidity.
Kemp. (Northern Ireland).	1.039 (15/10/34)	M. 0.49 T. 0.11 F. 8.7	(a) 1.030 (23/10/34) (b) 1.020 (16/4/35)	A rather poor quality cider with a very raw acidity.
Royal Codlin. (Northern Ireland).	1.046 (15/10/34)	M. 1.18 T. 0.16 F. 10.7	(a) 1.030 (24/10/34) (b) 1.022 (16/4/35)	Higher in quality than the previous sample but with an extremely penetrating acidity.
White Dutch. (Northern Ireland).	1.040 (15/10/34)	M. 0.98 T. 0.09 F. 10.0	(a) 1.030 (15/11/34) (b) 1.022 (16/4/35)	A cider with a very keen acidity, but having a very clean, fresh flavour.

COMPETITION CIDERS, 1934-35.

JUDGES AWARDS.

CLASS 1. KINGSTON BLACK. (4 Entries) (2 Prizes).

First Prize	..	J. Lang, Curry Rivel, Som.
Second Prize	..	L. E. Guilding, Bushley, Worcs.
Reserve	..	P. E. Bomford, Upton Snodsbury, Worcs.

CLASS 2A. SHARP VARIETIES.

(Acidity normally not less than 0.75 per cent.)

(17 Entries) (3 Prizes).

Variety.

First Prize	..	P. E. Bomford, Upton Snodsbury, Worcs.	..	Cowsden Bromley.
Second Prize	..	J. E. Bradley, Rockfield, Mon.	..	Rockfield Cowarne.
Third Prize	..	J. E. Bradley, Rockfield, Mon.	..	Frederick.
Reserve	..	W. T. Lewis, Usk, Mon.	..	Frederick.
Very Highly Com'ded		T. H. Golledge, Shepton Mallet, Som.	..	Cap of Liberty.
Commended	..	R. D. Lewis, Raglan, Mon.	..	Frederick.

CLASS 2B. MEDIUM SHARP VARIETIES.

(Acidity normally between 0.45 and 0.75 per cent.)

(31 Entries) (3 Prizes).

First Prize	..	E. T. Lewis, Dymock, Glos.	..	Dymock Red.
Second Prize	..	E. T. Lewis, Dymock, Glos.	..	Crimson Norman.
Third Prize	..	J. Halse & Son, Newton St. Cyres, Devon	..	Langworthy.
Reserve	..	J. Halse & Son, Newton St. Cyres, Devon	..	Crimson King.
Very Highly Com'ded		W. Wootton, Byford, Hereford.	..	Red Foxwhelp.
"	"	G. E. Tyley, Cheddar, Som.	..	Toogood Bitter.
Highly Commended		C. A. Jennings, Shapwick, Som.	..	Fair Maid of Taunton.
Commended	..	L. E. Guilding, Bushley, Worcs.	..	Peggies.

CLASS 3. SWEET VARIETIES. (27 Entries) (3 Prizes).

First Prize	..	H. Harris, Newton St. Cyres, Devon	..	Sweet Alford.
Second Prize	..	S. B. Neill, Woodbury, Devon	..	Sweet Alford.
Third Prize	..	C. A. Jennings, Shapwick, Som.	..	Hangdown.
Reserve	..	E. A. Scott, Ilminster, Som.	..	Woodbine.
Very Highly Com'ded		W. T. Lewis, Usk, Mon.	..	Prescoed.
Highly Commended		C. A. Jennings, Shapwick, Som.	..	Sugar Sweet.
Commended	..	A. Pope, Crediton, Devon	..	Sweet Alford.

CLASS 4A. MILD BITTERSWEET VARIETIES.

(Tannin normally below 0.3 per cent.)

(10 Entries) (3 Prizes).

First Prize	..	S. H. Osborn, North Cadbury, Som.	..	George James.
Second Prize	..	J. E. Bradley, Rockfield, Mon.	..	Perthyre.
Third Prize	..	H. Sealey & Son, Rodney Stoke, Som.	..	Stoke White Norman.
Reserve	..	S. B. Neill, Woodbury, Devon	..	Spotted Dick.
Highly Commended		S. W. Jones, Tregare, Mon.	..	Perthyre.
"	"	R. Evans, Norton Canon, Hereford	..	Cummy Norman.

CLASS 4B.

BITTERSWEET VARIETIES.

(Tannin normally above 0.3 per cent.)

(14 *Entries*) (3 *Prizes*).

First Prize	..	W. Wootton, Byford, Hereford.	Knotted Kernel.
Second Prize	..	G. E. Tyley, Cheddar, Som. ..	River Apple B.
Third Prize	..	P. J. Prosser, Norton Canon, Hereford	Knotted Kernel.
Reserve	..	R. J. Denning, Ilminster, Som.	Bitter Jersey.
Very Highly Com'ded		C. H. Chudley, Newton Abbot, Devon	Strawberry Norman.
Highly Commended		S. H. Osborn, North Cadbury, Som.	Royal Jersey.
Commended	..	J. E. Bradley, Rockfield, Mon. ..	Strawberry Norman.

CLASS 5.

PERRIES. (10 *Entries*) (3 *Prizes*).

First Prize	..	T. Fawkes, Stonehouse, Glos. ..	Huffcap.
Second Prize	..	A. J. Cook, Norton, Glos. ..	Oldfield.
Third Prize	..	T. H. Brookes, Uckington, Glos.	Butt.
Reserve	..	R. Hyett, Dymock, Glos. ..	Blakeney Red.
Highly Commended		T. H. Brookes, Uckington, Glos.	Oldfield.

LOW TEMPERATURE KEEVING OF CIDER.

By VERNON L. S. CHARLEY.

The practice of keeving, once so important a feature of cider-making procedure, has to a large extent been rendered obsolete by radical changes in the methods of manufacture of cider. This is a natural outcome of the fundamental changes that have taken place in the cider industry during this century whereby the bulk of the cider is now made in factories where, with the limited space available and the necessarily short season for the treatment of so large a quantity of fruit, the process of keeving, which is both time and space consuming, has become impracticable.

The details of the process are quite straightforward, although the principles underlying the practical manipulation are more involved. Fresh apple juice as it runs from the press contains a certain quantity of tissue and skin, the amount varying with the type of mill, with the nature of the "cheese" and with the cloths utilised to retain the apple pulp. Apart from the larger particles, juices retain varying amounts of very fine solids and colloidal materials. It has been recognised for centuries that every effort should be made to effect as complete a removal of all such material as is possible prior to fermentation.

The contention has been advanced that the process of fermentation definitely "dissolves" various compounds out of the solid tissues with deleterious results on the ultimate flavour. It is certain that the pieces of tissue and colloidal aggregates do harbour large numbers of yeasts and bacteria, including the causal organisms of cider disorders. The practice of keeving was developed to remove such deposits and as much of the biological flora of the cider as possible. The fresh juice was allowed to stand in large, open vats or casks for several days at a low temperature. The formation of a brown head, indicating that an appreciable separation of solid tissue was being effected, was followed by a careful racking of the juice to leave the brown head and the bottom deposit undisturbed. Properly carried out, keeved juices were practically clear, and were devoid of many compounds that would be likely to come out of solution later on and cause haze or deposits.

Apart from the biological significance of the practice of keeving, the chemical changes occurring during the process are of great

significance. The juice contains both pectin and pectase, the latter being an enzyme capable of removing pectin from solution. During keeing the pectase decomposes the pectin and thus removes from solution a complex compound whose degradation might cause a loss of clarity later in the history of the cider. Juices rich in pectase undergo more extensive clarification for this reason, and it has been the practice in some districts to supply additional pectase by the addition of pear juice. It is interesting in this connection to note that a variety of pear giving a juice with a high pectase content was cultivated in Switzerland solely for the purpose of aiding defecation in expressed apple juices.

The subject under consideration was brought into prominence once again in 1933, when the writer organised a tour in the French cider districts for members of the National Association of Cider Makers. One of the most interesting processes seen on the tour consisted in the keeing of apple juice on a very large scale at a temperature of about $4-5^{\circ}\text{C}$, which was maintained by employing powerful refrigerating machinery. The fact that artificial means of cooling the juice were employed on such a scale lent a new significance to the subject, and in consequence a series of preliminary experiments have been carried out at Long Ashton, which are described in this report.

Before proceeding to the experimental results, it is important to draw attention to the rôle of temperature in ordinary keeing and in the special type of process now being discussed. It has always been considered essential for keeing to be carried out at fairly low temperatures in order that the top and bottom deposits would be as little disturbed as possible by the commencement of fermentation. For this reason Warcollier recommends that, where possible, juices to be keeved should only be expressed during cold weather and on days when barometric pressures are likely to be equable.

It has been suggested, however, that the use of low temperatures of the order of $3-4^{\circ}\text{C}$ has a further effect. The inhibition of fermentation may be accompanied by a precipitation of certain classes of compounds whose solubility in the juice is a function of temperature. For example, certain materials which may be in true solution at $10-16^{\circ}\text{C}$ may be less soluble at $3-4^{\circ}\text{C}$ and consequently be partly deposited from solution. The removal, by refrigeration at this stage, of substances which are liable to separate out later on exposure of the cider to low temperatures is of obvious importance from the cider-maker's point of view.

The present experiments are being extended to determine the nature of the substances which are removed from solution under such conditions.

EXPERIMENTAL.

The preliminary experiments considered in this report were carried out on the following five freshly pressed juices :—

- No. 1. Mixed apples (medium sharp).
- No. 2. Redstripe (medium sharp).
- No. 3. Red Jersey (bittersweet).
- No. 4. Sweet Jersey (sweet).
- No. 5. Mixed culinary fruit (sharp).

Two ten gallon casks, together with a series of glass, gallon jars for observation purposes, were filled from each juice and used as material for the experiments. One cask and several jars from each juice were placed in a refrigerator at 2°C, and the corresponding control casks and jars placed outside the store at a temperature of 11°C. The juices were left in these positions for 6 days. During that period, the colder temperature varied between 2—3.5°C, whilst a sudden cold spell of weather reduced the temperature of the outside series of casks to 9°C. The juices were carefully racked at the end of the keeing process, and run into fresh casks or glass jars. The fermented ciders were filtered in a medium sweet condition and stored in casks and jars.

The visible effects of keeing at the low and higher temperatures are recorded in Table I.

The data given in Table I indicate that the lower temperature of keeing afforded in all cases except one a clearer juice, and if the temperature outside the cold store had been slightly higher it is probable that the results would have shown greater differences. The flocculent material was identical with that which is commonly found in low acid ciders and usually attributed to the formation of some form of pectin degradation product. In the case of juices Nos. 5 A and B, sufficient of the flocculent deposit was collected to carry out a few qualitative tests, and these tended to show that the material contained substances of pectous origin.

Changes in Pectin.

It was decided to follow the pectin changes in the keeved juices at both temperatures, and this was done by means of the Carré and Haynes calcium pectate method.

Table II includes some of the more interesting data.

TABLE I.
VISIBLE EFFECTS OF LOW TEMPERATURE KEEVING OF CIDER.

A = higher temperature 9—11°C.

B = lower " 2—3.5°C.

Juice.	Appearance 3 days after commencement of keeing.	Appearance 6 days after commencement of keeing.	Appearance of keeved juices after being racked.
No. 1 A ..	Slight deposit and "head"; still very cloudy.	Heavier deposit. Juice still cloudy.	As fresh juice.
No. 1 B ..	Same as 1 A.	Juice much clearer than 1 A.	Definitely clearer.
No. 2 A ..	Heavy deposit but very slight "head."	Juice still very cloudy. Heavy deposit with overlying flocculent material.	As fresh juice.
No. 2 B ..	Slight deposit and "head."	Juice almost clear. Heavy deposit of white flocks. Sides of jar also covered. (See 5 B below.)	Almost clear.
No. 3 A ..	Very little deposit.	Very little change.	Quite cloudy.
No. 3 B ..	Same as 3 A.	Same as 3 A.	do.
No. 4 A ..	Heavy deposit and some "head"	Juice much clearer.	Much clearer than fresh juice.
No. 4 B ..	Clearer than 4 A. Heavy deposit and considerable "head."	Juice quite clear. Heavy deposit with overlying flocks of white material.	Quite clear.
No. 5 A ..	Juice fairly clear. Definite signs of flocculent pectin deposit and gel formation in the "head."	Juice hazy. Much flocculent material deposited.	Slight haze.
No. 5 B ..	Juice clear; heavy bottom deposit and large clots formed on top.	Juice clear, sides of jars covered with white flocculent deposit; $\frac{1}{8}$ " light material formed on top of heavy bottom deposit.	Quite clear. Sufficiently bright for bottling.

TABLE II.

CHANGES IN CALCIUM PECTATE CONTENT DURING KEEVING OF JUICES.

A=higher temperature.

B=lower „

Juice.	Calcium pectate per cent.			
	In fresh juice.	Juice keeved 3 days.	Juice keeved 6 days.	Juice racked after keeving.
No. 1 A ..	0.0836	0.0520	0.0324	0.0301
No. 1 B ..	do.	0.0690	0.0550	0.0547
No. 2 A ..	0.0328	0.0267	0.0220	0.0220
No. 2 B ..	do.	0.0301	0.0297	0.0286
No. 3 A ..	0.0531	0.0430	0.0355	0.0351
No. 3 B ..	do.	0.0496	0.0389	0.0382
No. 4 A ..	0.0364	0.0268	0.0204	0.0205
No. 4 B ..	do.	0.0328	0.0294	0.0291
No. 5 A ..	0.1353	0.0963	0.0445	0.0440
No. 5 B ..	do.	0.1210	0.0849	0.0831

The results indicate that in every case the juices stored at the lower temperature retained a larger proportion of pectous material than those juices which were kept in the warmer position. The chemical results as given in Table II are most satisfactorily explained by assuming that the temperature in the cold store not only prevented fermentation but also retarded to a marked degree the action of the pectin-decomposing enzyme, pectase. But whilst this assumption can be regarded as explaining the chemical data, the data themselves are not in accord with the suggestion that the removal of pectin from solution is responsible for the enhanced clarity of the juice. Briefly stated, the facts elucidated by observation and analysis are these:—juices after storage at 2°C, whilst giving appreciably higher amounts of calcium pectate than similar juices stored at 9°C, were definitely clearer than the latter series. In the absence of further analytical data, it would seem likely that the clarification of the juices has been caused by the removal from solution of other compounds as well as pectous materials. When other likely materials are being considered, it is of interest to observe the accentuated effects that were obtained in the case of samples Nos. 5 A and B. The juice was a blend of sharp culinary sorts, and although the initial pectin content was conspicuous for its high value, the two juices stored at 9°C and 2°C gave the most satisfactory clearing during storage. It is possible that some at least of the effect was caused by changes in the state of the various classes of nitrogenous compounds in the juice. Market apples are generally characterised by relatively high nitrogen contents, and it is of interest to note that in a previous

season a remarkably good clarification was obtained by the use of a protein-decomposing enzyme on a high nitrogen Bramley's Seedling juice (1), whereas no effects were observed when cider juices were similarly treated. Various experiments which have been made with other juices have confirmed the observation that high nitrogen juices are more susceptible to clarification than those with lower amounts of this constituent.

Experiments are now in progress to determine whether it is possible to obtain better clarification of juices by the addition of sufficient quantities of various pectinous or nitrogenous compounds without prejudicing the flavour, stability or clarity of the ultimate products.

Effect of Kieving Treatment on Subsequent Fermentation.

The juices were racked from the lees on 16/12/34 and allowed to ferment at ordinary temperatures. A second cold spell occurred immediately after racking and held back the fermentations to some extent at that time. The gravities of the fresh juices and of the liquors after racking and at two stages during fermentation are given in Table III.

TABLE III.
SPECIFIC GRAVITIES OF FERMENTING JUICES PRIOR AND SUBSEQUENT TO
KEEVING AT TWO TEMPERATURES.

A=higher temperature.
B=lower ,,

Juice.	Specific Gravity.			
	Fresh juice.	After racking 16/12/34.	27/12/34.	3/1/35.
No. 1 A ..	1.045	1.040	1.027	1.020
No. 1 B ..	do.	1.044	1.040	1.032
No. 2 A ..	1.050	1.045	1.040	1.037
No. 2 B ..	do.	1.048	1.045	1.039
No. 3 A ..	1.045	1.041	1.030	1.025
No. 3 B ..	do.	1.044	1.040	1.033
No. 4 A ..	1.045	1.042	1.035	1.032
No. 4 B ..	do.	1.045	1.042	1.034
No. 5 A ..	1.044	1.037	1.007	1.001
No. 5 B ..	do.	1.040	1.029	1.003

It will be seen that the keiving at 2°C has temporarily retarded the subsequent fermentation. The juices from the cold store were removed, after being racked, to a warm room and brought to the

same temperature as the outside casks within 6 hours. The effects are more noticeable on 27/12/34, and on this date the gravities of the juices 5 A and B were 1.007 and 1.029 respectively. The ciders were pulp filtered at appropriate gravities for the acidity of each sample, and observed over a period of months. Unfortunately, the filtration was not sufficiently effective on account of the small quantities of juice in each experiment calling for the use of a small filter which could not be sufficiently tightly packed. No significant differences were noted in the condition or flavour of the ciders.

SUMMARY.

1. Samples of comparable apple juices were keeved for one week at two temperatures, 9°C and 2°C respectively. The juices stored at the lower temperature were considerably clearer than the corresponding samples at the higher temperature, especially in the case of a mixed culinary apple juice where remarkable clarification was obtained.

2. Calcium pectate data showed that the juices stored at the lower temperature, which effected more efficient clarification, retained larger quantities of pectin than the other juices. The possible effect of nitrogenous materials on the clearing of juices is discussed.

3. The juice in which most clarification occurred was made from market varieties of apples and contained initially the greatest quantity of pectin.

4. Keeving at low temperature (2°C) temporarily retarded subsequent fermentation.

REFERENCE.

- (1) CHARLEY, V. L. S. *Ann. Rept. Agric. and Hort. Res. Sta., Long Ashton*, p. 246, 1934.

EXPERIMENTS ON THE IMPROVEMENT OF THE JUICE FROM CULINARY AND DESSERT APPLES BY MACERATION WITH PRESSED BITTERSWEET POMACE.

PROGRESS REPORT III.

By P. T. H. PICKFORD.

During the cider making season of 1934, this series of experiments was continued on similar lines to those of 1932 and 1933 (see Long Ashton Report 1933 and 1934).

The object of these experiments, which are concerned with the utilisation of lower grade market apples for cider, has been fully described in the first contribution to the series, in which it was also shown that a definite improvement of the juice from market apples was brought about by maceration with pressed bittersweet pomace.

The second year's experiments confirmed the initial results and in addition showed that the maceration period previously used could be substantially shortened.

In the 1932 experiments, the once-pressed pomace from bittersweet apples was re-soaked with juice obtained from an equivalent weight of market apples and allowed to macerate for prolonged periods before pressing. The 1933 investigations were a repetition of the previous year's treatment but, in addition, one batch of juice was pressed immediately with pressed bittersweet pomace. The latter method gave approximately the same degree of improvement as the prolonged maceration treatment and was found to be simpler.

The third season's experiments here described have confirmed the results previously obtained, and have also shown how the treatment of maceration may be adopted under practical conditions where the proportion of bittersweet apples available for blending with market varieties is limited.

Experimental.

The 1934 experiments were four in number. In each, prolonged maceration of the pomace was dispensed with in view of the 1933 results and this material was accordingly taken to the press immediately after treatment. The details of the experiments were as follows :—

Experiment I. Juice from 5 cwts. of Lane's Prince Albert was re-pressed with once pressed pomace from an equivalent weight of Knotted Kernel.

Experiment II. Juice from 5 cwts. of Lane's Prince Albert was re-pressed with the unpressed pomace from an equivalent weight of Knotted Kernel.

Experiment III. Equal proportions of Lane's Prince Albert and Knotted Kernel were milled together.

Experiment IV. Juice from 3 cwts. of mixed culinary varieties—equal parts of Bramley's Seedling and Newton Wonder—was macerated with once pressed Bitter Jersey pomace and the final juice blended with the pure juice from 1 cwt. of Bitter Jersey.

The analyses of the juices are shown in Table I on page 147.

Discussion of Results.

In Experiments I, II, and III, Knotted Kernel was, unfortunately, not typical of this variety, the juice being unusually high in acidity and low in tannin, whilst the rate of fermentation of the juice was abnormally quick. The quality of the cider was only fair and bottled samples showed that considerable secondary fermentation developed with age. Lane's Prince Albert was, however, a typical juice from this type of fruit. It produced a poor quality cider lacking in body and having a pronounced raw, acid character. The specific gravity of the fresh juice and the tannin content were low, while the percentage of malic acid was high.

In Experiment I, where the juice of Lane's Prince Albert was soaked with once pressed Knotted Kernel pomace, the specific gravity of the juice was increased to a considerable degree by the treatment, while the acidity was appreciably reduced. The tannin value was shown to be only slightly higher ; but, as explained in the previous report, the method of analysis used does not give a true indication of the tannin character in the juice after maceration. The increase in the general bittersweet character of the liquor brought about by the treatment may be measured approximately from a comparison of the acidity figures. The rate of

TABLE I.

<i>No. of Experiment.</i>	<i>Variety.</i>	<i>Treatment.</i>	<i>Date of Making.</i>	<i>Specific Gravity of Fresh Juice.</i>	<i>Malic Acid per cent.</i>	<i>Tannin per cent.</i>	<i>Rate of Fermentation.</i>	<i>Date of Filtering.</i>	<i>Specific Gravity at time of Filtering.</i>	<i>Specific Gravity, May, 1935.</i>
I	Knotted Kernel ..		9/11/34	1.057	0.39	0.20	8.7	24/11/34	1.025	1.020
	Lane's Prince Albert		9/11/34	1.038	0.80	0.05	10.0	17/11/34	1.030	1.023
	Lane's Prince Albert	Juice from 5cwt. Lane's Prince Albert pressed with pomace from 5cwt. Knotted Kernel	9/11/34	1.048	0.69	0.07	11.0	19/11/34	1.030	1.023
II	5cwt. Lane's Prince Albert, 5cwt. Knotted Kernel ..	Juice of Lane's Prince Albert pressed with milled Knotted Kernel apples	9/11/34	1.052	0.63	0.12	9.3	20/12/34	1.030	1.023
	5cwt. Lane's Prince Albert, 5 cwt. Knotted Kernel ..	Fruit mixed at time of milling	9/11/34	1.052	0.64	0.12	8.2	22/11/34	1.030	1.020
IV	Bitter Jersey ..		5/12/34	1.048	0.30	0.27	6.0	14/12/34	1.025	1.022
	Mixed Culinary Apples		5/12/34	1.045	0.77	0.07	7.0	13/12/34	1.030	1.027
	3cwt. Mixed Culinary Apples, 1cwt. Bitter Jersey	Juice of Mixed Culinary Apples pressed with Bitter Jersey pomace and blended with the Bitter Jersey Juice ..	5/12/34	1.046	0.63	0.13	6.5	11/12/34	1.030	1.027

fermentation of the treated juice was slightly higher than the untreated juice, according to the incubation test at 25°C, although there was very little difference in their rates of fermentation in the cider-house and both samples had fallen to a similar specific gravity by the following May.

Juice analyses indicated little difference in composition between the products of Experiments II and III, where in the one case the culinary juice was re-pressed after it had been poured over the unpressed bittersweet pomace and in the other where the fruit was mixed before pressing. A considerably slower fall in specific gravity was shown in the case of the former treatment, however, after the samples had been stored for several months.

When the samples were examined the following May, the results were found to correspond to those obtained in the previous years. The flavour of the juice from Lane's Prince Albert was distinctly altered by the treatment with the pressed Knotted Kernel pomace, and there was a very marked improvement in the resulting cider, which was definitely fuller in flavour and had considerably more character than the untreated juice, while the acidity was softer to the palate and a pleasant, mild bitter character had been introduced by the treatment.

Comparison of the two blends of equal parts of Lane's Prince Albert and Knotted Kernel (Experiments II and III) furnished an interesting feature of the experiments. Although very little difference was shown by the analytical figures in the composition of the two juices, yet there was a marked difference in their flavour. The blend of the culinary juice with the unpressed bittersweet pomace resulted in a cider of considerably higher quality than that obtained from mixing the apples. The acid and tannin characters were more refined in the former and became better blended with the flavour of the cider as a result of the maceration treatment.

In Experiment IV the Bitter Jersey material was fair in quality but had a rather coarse tannin character, and the specific gravity of the fresh juice was somewhat disappointing. The culinary juice, which was a blend of equal parts of Bramley's Seedling and Newton Wonder, yielded quite a pleasant cider of its type, but it lacked fullness of character and had a very penetrating, acid flavour. It was, in fact, a typical example of juice from culinary varieties, being high in acidity with a very low tannin content and at the same time having a low original gravity.

In the following May the blend prepared in this experiment was found to have made a very pleasant cider. It was of very much

higher quality than a cider prepared from the same original fruit and obtained by blending the bittersweet and the untreated culinary cider in a similar proportion. In fact a cider of comparable quality was only achieved by the latter procedure by blending one part of bittersweet juice to two parts of untreated culinary juice.

Conclusions.

It is shown by the experiments that a considerable amount of the bittersweet character can be introduced into the juice obtained from market apples by re-pressing the latter with pressed bittersweet pomace.

The quality of a blend made from equal proportions of market apples and bittersweet cider apples can be improved to an appreciable extent by re-pressing the juice obtained from the market apples with unpressed bittersweet pomace.

A cider of fair quality can be produced with one part of bittersweet cider apples to three parts of market apples by re-pressing the juice from the market apples with the bittersweet pomace.

INVESTIGATIONS ON FRUIT PRODUCTS.

V.—THE CONCENTRATION OF FRUIT JUICES BY FREEZING, WITH SPECIAL REFERENCE TO APPLE JUICE.

By VERNON L. S. CHARLEY.

Concentration of apple juice has been carried out for a number of years both as a means of preserving the juice in an unfermented condition and as an economical way of storing and transporting the product. The concentrate is sold to mineral water manufacturers for the preparation of apple drinks, and to cider makers for dilution and subsequent fermentation. A certain domestic trade also exists for the concentrated juice, but the quantity sold in this way is not large.

The process, however, has certain limitations, especially when the more acid types of juices are considered, and it is essential to realise that concentration cannot be used to intensify aroma and flavour, for apart from the fact that there is usually a deterioration in these characters during evaporation, the final product is in a concentrated state and needs to be diluted before it is in a suitable form for consumption. The sugar and acid percentages are increased by the evaporation and when subsequent dilution has reduced these constituents to their normal percentages, the aroma and flavour are similarly reduced in intensity. Again, concentrates intended to be sold for subsequent dilution for beverage purposes must be manufactured from juices whose constituents are correctly balanced in sweetness, acidity and other essential characters before the concentration is effected. Most fruit juices, with the exception of grape and apple, are both too acid and insufficiently sweet for consumption in the natural state, and whilst concentration to the appropriate degree would remedy the sugar deficiency, the acidity would be correspondingly increased, leaving the concentrate as unbalanced in flavour as the fresh juice.

To illustrate this point it will be convenient to consider two types of juices, namely those which are capable of being consumed without requiring any appreciable alteration in their composition, and those whose chemical characters and acid content in particular render

them quite unsuitable as beverages in their natural form. An example of the first class is the apple. It is possible by careful blending of apple juices of different composition to obtain a blended juice which is correctly balanced in respect of sweetness and acidity. Such a balanced juice can be evaporated to one seventh of its original volume and on re-dilution the composition will be essentially the same as before concentration, and the juice will be ready for consumption. Concentration in such cases has been effective in preserving the juice from fermentation and naturally storage room for only one seventh of the volume of juice treated has to be provided.

In the case of the second class of juices, of which loganberry and black currant are examples, the acidities, ranging from 1.8—3.0%, as malic acid, are always extremely high, and on concentration or re-dilution of the concentrate, the juice is still unfitted for consumption. The high acidity also exerts a potent effect on flavour when concentration by heating in vacuo is adopted, and very low temperatures and high vacua are needed to reduce this effect to a minimum.

The chief object in concentration is to increase the total sugar content to about 65%, at which percentage fermentation is inhibited. The alternative method for preservation is to add sugar until a similar concentration is reached. This virtually implies a serious two-fold dilution of the original juice before it is consumed. In the first place the initial addition of sugar itself constitutes an appreciable dilution. The addition of 45% of sugar (8 lbs. per gallon) increases the volume of the original juice by nearly 40%, whilst two volumes of heavy syrup (65% sugar) are prepared from only one volume of juice. This dilution necessarily exerts an adverse effect on the intensity of flavour of the beverage, especially as the syrup has to be further diluted with water before being consumed. However, such syrups can be made entirely in the cold, and as the retention of fresh aroma and flavour to the maximum degree is thus possible, such syrups compare quite favourably with similar samples concentrated in vacuo. The vacuum evaporated samples are vitiated in quality to some extent by reason of the heat treatment. Although elaborate glass-lined vacuum concentrating tanks enable products to be manufactured to-day which possess only very slight "cooked" tastes, it is possible in nearly all cases to determine by tasting whether a product is a syrup or a concentrate. The differences between the two types of product can be summed up in this way:—Syrups possess flavours that are weaker in intensity but fresher and more characteristic of the fruit than concentrates.

There are several ways in which the concentration of apple and

other fruit products may be of importance. In the cider industry, for example, the storage of the very large bulks of juice and cider is extremely costly, and if a proportion could be economically concentrated during the making season, and held in a concentrated state until suitable accommodation became available, a great saving in storage costs would be effected. In the case of the apple, the concentrated juice could be sold as such for dilution in the home. Such products at present suffer from a pasteurised flavour, which is slight in many cases but unattractive in a considerable number of products.

It would be possible to concentrate certain ciders until the alcohol content was sufficiently high to afford complete stability to the product, or again, by using a low acid cider, palatable products of the liqueur type could possibly be produced by such a process.

In view of the position outlined above, any process that enables fruit juices to be concentrated without encountering the deleterious effects of the heat treatment would be of great use in the products industry. Such a process was developed to a certain point by Professor Eudo Monti and was used on a commercial scale in Italy several years ago. The juice is exposed to a low temperature and a crop of pure ice crystals is formed. When the solid phase is sufficient to warrant its removal, the sludge of ice and juice is drained or centrifuged and the withdrawal of the ice leaves the juice in a concentrated condition. The process is repeated, lower temperatures being needed for each successive operation, for the freezing point of the juice is lowered as it becomes progressively richer in soluble solids. By this means, juices containing originally 10-15% sugar can be concentrated until 45-55% sugar are present. The process has not made much headway since it was introduced, for many mechanical difficulties are involved. The complete removal of the juice from the ice is a matter of difficulty, and the hitherto high cost of electric power has made the refrigeration costs prohibitive. In view, however, of the progressively reduced costs of freezing, and of the importance of arriving at some method of concentration which does not adversely affect the flavour or other characters of the juice, it was decided to investigate the method from the point of view of superiority of product over that given by other methods, and to determine the most satisfactory mechanical and physical conditions for separating the ice from the concentrate.

References to the process are scanty if the original communications by Monti (in Italian) are excluded. Irish,(1) referring to the freezing method, mentions that two or three freezings are necessary to obtain a sugar content of 50-55%. Pineapple concentrate has

been produced in the Hawaiian Islands by this method. Distinction is made between the original method of Monti in which the syrup was merely drained away from the ice, and that of H. C. Gore of New York,(2) where the centrifuge was first used. Irish further includes the "Ice Plant Method" in his survey of methods of concentrating fruit juices. Details are not given but it is said that many of the disadvantages of the previous method are overcome.

Morris (3),(4) has published the results of two series of experiments on the concentration of orange juice by freezing and the storage of the product. The frozen juice was centrifuged in an ebonite cage with holes 2mm. in diameter. Quick freezing resulted in the formation of small ice crystals which tended to retain the concentrate to a greater degree than the larger crystals formed during slow freezing. The juices were frozen quickly in brine at -28°C . (to inhibit enzyme action) until ice began to appear, and then a slower freezing was maintained at -10°C . or lower, until sufficient ice was formed to make it worth while using the centrifuge. To obtain a good yield two centrifugings were necessary, first when the liquid phase contained 25-30% soluble solids, and again later when the solids reached 45% or over. The liability of orange juice to absorb unpleasant or stale flavours and the necessity for scrupulous cleanliness in utensils, etc. and the prevention of contact of concentrate with iron or copper was observed.

The concentrates were stored at -20°C ., -10°C ., and at room temperature, and in some cases of products stored at ordinary temperatures, clots were formed, which were presumably due to the conversion of pectin to pectic acid.

The method is referred to by O. Grove (5) in 1930. No experimental data are given but the freezing process was combined with evaporation in vacuo. A single freezing was followed by centrifugation and the resultant juice concentrated to the desired density by heat.

The latest development along these lines was studied by members of the National Association of Cider-makers on their tour of the German cider and wine districts in September, 1935. The process was being developed by Dr. Krause of Munich, and an experimental plant was seen in operation on red currant juice at Wiesbaden. Further, a large commercial installation was studied by the writer by the courtesy of Dr. Krause and the firm of Englehardt, at Karlsruhe. The process involves the freezing of a narrow cylindrical mass of juice in the midst of which rests a network of stainless steel strips to support the block of ice crystals which is eventually formed. The hollow cylinder of ice, in which the crystals have been

laid down in symmetrical fashion to allow the juice to run away freely, is centrifuged, and the concentrate returned to the freezing chambers for a second treatment. The ice remaining in the centrifuge is used to cool the brine. Most of the products were conspicuous for their fresh flavour, but as some concentrates had been prepared from pasteurised juices, it was impossible fully to assess the effect of the procedure on flavour.

The preliminary experiments which are discussed in this report were carried out to determine the nature of the problems involved in the freezing process, and whether the differences in flavour between concentrates produced by heat or cold methods were sufficiently important to merit further investigation.

EXPERIMENTAL.

A small cold store of approximately 300 cu. ft. capacity and cooled by methyl chloride was installed for these and other experiments on fruit juices involving the use of low temperatures. The store could be thermostatically controlled at $+4^{\circ}\text{C.}$ or -10°C. , and by running the engine continuously the temperature could be reduced to -25°C.

A small hand-operated crystal separator was used for the removal of the juice from the ice. This machine—the only one available for these initial experiments—proved to be very difficult to manipulate. As the basket was fixed vertically and without any upper support it was necessary to obtain a very even pack of ice to prevent an uneven movement which would quickly destroy the gears. Again, it was impossible to work the separator at a speed which efficiently removed the concentrated juice from the ice, thus impairing yields. However, products were obtained with satisfactorily high gravities, and the question of yield, in a series of qualitative experiments such as is now under consideration, is not of primary importance.

A large number of juices were concentrated by freezing, but details of one series only are given here.

Freezing Experiments.

A mixture of Sweet Alford and Woodbine juice made on 23 11/34 was used for a series of four freezing experiments. The analysis of the blend was as follows: - specific gravity 1.045, acidity (as malic acid) 0.39%, tannin 0.16%. The course of the first experiment only is given in some detail. A quantity of $5\frac{1}{2}$ gallons of blended juice at 11°C. was placed with three other lots in the cold store at 11.30 a.m. on 26/11/34, the temperature of the store being -12°C.

and the motor running continuously. The temperature of the juice fell rapidly, and 4 hours later had fallen to $-0.5^{\circ}\text{C}.$, the store being at $-16^{\circ}\text{C}.$; after eight hours the juice was at $-2^{\circ}\text{C}.$, and the store temperature $-18^{\circ}\text{C}.$ The juice now appeared to be quite thick with crystals and was centrifuged at 8 p.m. The analyses of the concentrate and ice after being suitably brought to a temperature of $15.5^{\circ}\text{C}.$ were as follows:—

Concentrate :	Specific gravity	1.056	acidity	0.47%	tannin	0.17%
Ice :	„	1.007	„	0.09%	„	0.02%

The ice was quite white except for specks of apple tissue scattered throughout. Five lb. of ice and 5 gallons of juice were collected, and the latter returned to the cold store. As it was not desired to obtain a solid block of juice and ice, the store was maintained at $-12^{\circ}\text{C}.$ throughout the night instead of using a lower temperature, and the material centrifuged at 4 p.m. on 27/11/34. $3\frac{1}{2}$ gallons of concentrate and $11\frac{1}{2}$ lbs. of ice were obtained. The analyses were as follows :

Concentrate :	Specific gravity	1.071	acidity	0.53%	tannin	0.21%
Ice :	„	1.009	„	0.06%	„	0.02%

Further quantities of 12 lbs. of ice and 2 gallons of concentrate were obtained at noon on 28/11/34, when the cold store still remained at $-12^{\circ}\text{C}.$ The analyses were as follows :

Concentrate :	Specific gravity	1.107	acidity	0.73%
Ice :	„	1.010	„	0.09%

The cold store was then run continuously and by 10 a.m. on 30/11/34 the temperature was $-18^{\circ}\text{C}.$ and the concentrate again appeared to be quite thick with crystals. The next centrifuging was carried out in the cold store itself and during this period the temperature rose gradually to $-12^{\circ}\text{C}.$ 1 gallon of concentrate and 8 lb. of ice, rather yellow in appearance, were separated. The analyses, which show that an appreciable increase in gravity had been effected, are given here :

Concentrate :	Specific gravity	1.164	acidity	1.03%	tannin	0.43%
Ice :	„	1.022	„	0.14%	„	0.10%

A further centrifuging on 1/12/34 at $-25^{\circ}\text{C}.$ again removed an appreciable quantity of ice, in which, however, was retained a quantity of concentrated juice. Four lbs. of very yellow crystals were collected, and the volume of concentrate was reduced to 5 pints (2,850 c.c.'s). The analyses were as follows :

Concentrate :	Specific gravity	1.227	acidity	1.50%	tannin	0.80%
Ice :	„	1.060	„	0.45%	„	0.12%

At a later date a small portion of the concentrate was again frozen at -25°C . and centrifuged. The separation was very incomplete, due to the inefficiency of the separator, and whilst the gravity of the concentrate rose to 1.264, the ice, on being melted and brought to 16°C ., showed a gravity of 1.130.

The net result of the series of treatments was that from $5\frac{1}{2}$ gallons of fresh juice with a gravity of 1.054 were produced 5 pints of concentrate with a gravity of 1.227.

These data clearly indicate the deficiencies of the method of separation as used in the experiments for, whereas the concentration as shown by the gravity figures is between 1:4 and 1:5, only one ninth of the initial bulk of juice was collected as concentrate. With the apparatus available it was impossible to obtain a more efficient separation, but for further experiments a mechanically driven machine is being used.

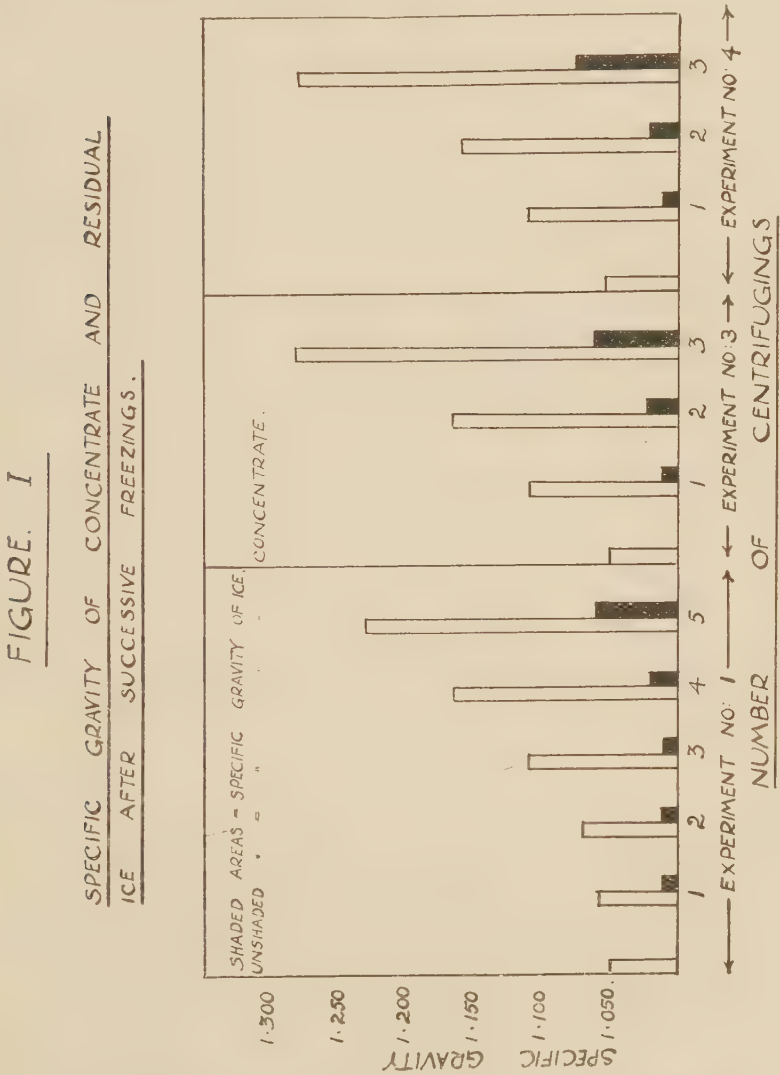
The effects of the various centrifugings on three different lots of the Sweet Alford-Woodbine blend are illustrated graphically in Figure I. The earlier centrifugings were uneconomical, and it is probable that the best procedure would be to freeze the juice slowly and, by reducing the temperature to a suitable extent, to obtain a thick sludge of ice crystals. The appearance of any bulk of material at this stage of freezing is deceptive, for it has often been noticed that the "frozen" mass appears to be full of crystals, whereas at the commencement of centrifuging, only a small quantity of ice has actually formed. The first centrifuging should not be carried out until the juice is actually almost solid with ice. If this is done, and if a very low temperature is available for the succeeding freezing, it should be possible to make concentrated juices with 50—55% sugar (specific gravity 1.23—1.26) by two centrifugings only.

Flavour Tests.

In order to obtain a comparison with the series of concentrates produced by the freezing process, a number of similar juices were evaporated in a large glass flask at a temperature not greater than 35°C . and under a vacuum of 28.5 inches. The vacuum evaporation was thus carried out under ideal circumstances, and the concentrates produced in this way were notable for their very slight pasteurised taste. Concentration was taken to a stage approximately equal to that of the product obtained by the freezing method. The concentrates from both methods were produced simultaneously, and were stored as follows :

December, 1934,—February, 1935, at 1°C. in the fruit cold store.
February, 1934,—January, 1936, at 5°C. in the store used for the
freezing experiment.

Concentrates which were pasteurised were treated at 160°F. for
half an hour.



Representative data, abstracted from the full experimental
results, are given in Table I.

TABLE I.

FLAVOUR AND OTHER CHARACTERS IN APPLE JUICE CONCENTRATES.

No.	Juice.	Treatment.	Specific Gravity of Concentrate.	Preservation of Concentrate.	Condition of Concentrate.	Flavour of Diluted Concentrate.
1.	Sweet Alford Woodbine Blend	Freezing Concentration	1.255	Unpasteurised (U.P.)	Dark red ; heavy flocculent deposit. Very slight gas evolution on dilution.	Fresh apple flavour.
2.	Woodbine	"	1.215	U.P.	Light red ; clear but heavy deposit.	Clean fresh flavour, typical of Woodbine juice.
3.	"	"	1.214	Pasteurised (P.)	Dark red ; brilliant liquid but heavy deposit.	Only slight pasteurised flavour.
4.	Stable Jersey	"	1.197	U.P.	Same as 2.	Fresh flavour. Keen and brisk.
5.	"	"	1.215	P.	Same as 2.	Decidedly less brisk than 4. Pasteurised taste not obtrusive.
6.	Dabinett	"	1.220	U.P.	Cloudy liquid. Heavy deposit Some gas.	Clean fresh apple juice flavour Pleasant aroma.
7.	"	"	1.220	P.	Cloudy liquid. Heavy deposit	Heavier flavour but still pleasant and fruity.
8.	"	Vacuum Evaporation	1.220	U.P.	Same as 6.	No aroma. Quite brisk but faint "cooked" flavour.
9.	Red Jersey	Freezing Concentration	1.225	U.P.	(cloudy. Heavy deposit. No gas.	Very fresh apple flavour. Similar to freshly expressed juice.
10.	"	Vacuum Evaporation	1.229	U.P.	Cloudy. Heavy deposit. No gas.	Definite pasteurised taste. Quite distinct from 9.
11.	Sweet Alford.	Freezing Concentration	1.259	U.P.	(cloudy. Heavy deposit. Slight gas.	Clean flavour with definite mature taste.
12.	"	"	1.259	P.	Cloudy. Heavy deposit. No gas.	Slight pasteurised taste.
13.	"	Vacuum Evaporation	1.269	U.P.	Cloudy. Heavy deposit. No gas.	Slight pasteurised flavour. Not unpleasant.
14.	"	"	1.269	P.	Cloudy. Heavy deposit. No gas.	Definite "cooked" taste.

The observations included in Table I indicate that there is no difficulty in distinguishing between concentrates produced by the freezing and evaporation methods. The differences would probably be more accentuated in actual commercial practice, as the vacuum evaporation was carried out in these experiments in glass vessels and at very low temperatures which procedure would probably be uneconomical in practice. There is no doubt that the cold process affords the better product.

The storage of the concentrate when once produced has not yet been studied to any extent, but the results obtained in the foregoing experiments indicate that the products with 45% or more of sugar (specific gravity, 1.200 or higher) have kept fairly satisfactorily for a period of twelve months. The greater the degree of concentration, the more remote will be the chance of fermentation, and in commercial practice it will be advisable to adopt a minimum sugar standard of 55%. The storage of concentrates at temperatures slightly above 0°C. is satisfactory from the point of view of prevention of fermentation, but experience in the citrus juice industry shows that at such high temperatures there is likely to be some deterioration in flavour. A further possibility is the addition of sufficient sugar to raise the gravity to a safe figure. This would only be feasible where the concentrate from the freezing and centrifuging treatments is already reasonably high in gravity. The dilution of fruit flavour associated with the addition of sugar in excess of about 10% would be appreciable, but concentrates with a sugar content of 40–50% could be improved in stability by the addition of 5–10% of solid sugar. The use of small amounts of sulphur dioxide would also be helpful in retaining the concentrate in a fresh condition. Amounts up to 200 parts per million would not be detrimental to taste, in view of the ultimate dilution of the concentrate with water before being consumed.

Concentration of Cider.

Owing to the difficulties encountered in the use of the crystal separator it was not possible to carry out any effective tests on the concentration of cider, but preliminary trials with the following three ciders were made:—Knotted Kernel, Sweet Clusters, and Woodbine.

The analytical data for the juices and for the concentrated products after one freezing at -12°C . are given in Table II.

TABLE II.
FREEZING CONCENTRATION OF CIDER.

CIDER	ANALYSIS OF CIDER				ANALYSIS OF CONCENTRATE			
	Specific Gravity	Acidity Per Cent.	Tannin Per Cent.	Alcohol Per Cent. by Weight.	Specific Gravity	Acidity Per Cent.	Tannin Per Cent.	Alcohol Per Cent. by Weight.
Knotted Kernel	1.008	0.37	0.23	5.25	1.016	0.61	0.40	8.55
Sweet Clusters	1.0185	0.26	0.18	3.02	1.039	0.54	0.34	6.02
Woodbine	1.010	0.39	0.14	4.32	1.0195	0.65	0.27	8.15

The ice obtained was very low in gravity (1.001–1.004) but in the case of Knotted Kernel, 1.28% of alcohol was present.

The analyses of the concentrated ciders illustrate the impossibility of increasing one constituent in the original product without simultaneously raising the percentages of the accompanying compounds, and the use of the method to obtain ciders with higher alcoholic contents is limited by this consideration to the special cases where apples of the sweet class have been used exclusively in the making.

SUMMARY.

1. Concentrated apple juices have been produced by means of freezing and subsequent removal of ice. Sugar contents in the concentrates have ranged between 45 and 55%.
2. The flavour of concentrates produced in this manner has been shown to be more attractive than that of vacuum evaporated samples.
3. Three ciders have been concentrated by the cold process. The alcohol contents have been nearly doubled by this means.

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INVESTIGATIONS ON FRUIT PRODUCTS.

VI.—FRUIT SYRUPS.

A. PRODUCTION OF FRUIT SYRUPS.

B. USE OF PURE FRUIT SYRUPS IN MILK BEVERAGES.

By VERNON L. S. CHARLEY.

The preliminary investigations into the production of syrups from low grade fruits were discussed in the Annual Report of this Station for 1932 (page 175). It was shown that attractive products of this type could be prepared and details for the various kinds of fruit syrups were given. The experimental programme has been extended since the last report was published, and special attention has been given to the preservation of low sugar syrups with SO_2 .

The present paper gives the results of the 1934 and 1935 seasons' experiments, together with some general recommendations for the production of syrups for beverage purposes. Data obtained in the recent work, which has been carried out on the use of pure fruit syrups in combination with milk (milk shakes), follows in the second part of the paper, which includes recommendations for the production of syrups for this purpose.

A. THE PRODUCTION OF FRUIT SYRUPS.

Tables I and II contain the more important data concerning the preparation and quality of the syrups made during the summers of 1934 and 1935. The following points arise from a consideration of the detailed observations in the various columns :—

TABLE I.
DETAILS OF SYRUPS MADE IN THE 1934 SEASON. (Observations Made in February-March 1936).

No.	Fruit.	Additions per Cwt. of Crushed Fruit	Macer- ation	(1) Yield of Juice, in galls.	Syrup.			Flavour of Diluted Syrup.
					Sugar Content	Method of Preservation.	Appearance.	Flavour.
1	Strawberry	1 gall. water + $\frac{1}{2}$ gall. syrup.	2 days	9	38	Pasteurised for $\frac{1}{2}$ hour at 165°F.	Slight haze.	Flavour good until one year after making; then became less fruity.
2	do.	do.			45	do.	do.	Fuller than No. 1.
3	do.	do.			60	—	do.	Fresh fruit flavour, but deficient in acid and intensity of flavour.
4	Red Currant	1 gall. water + $\frac{1}{2}$ gall. syrup.	5 days	9	30	Pasteurised as above.	Brilliant red.	Fresh clean taste but not reminiscent of any definite fruit.
5	do.	do.			45	do.	Very deep brilliant red	Similar to No. 4.
6	do.	do.			60	—	Slight haze.	do.
7	do.	do.			30 (glucose)	Pasteurised as above.	Slight haze.	Unsat-is-factory. "Off" flavour
8	do.	do.			45 (glucose)	do.	Pale colour.	do.
9	do.	do.			60 (glucose)	—	Cloudy.	do.
10	do.	do.			50 (glucose)	—	Pale colour.	do.
11	Black Currant	1 gall. water + $\frac{1}{2}$ gall. syrup.	9 days	7 $\frac{1}{2}$	35	Pasteurised as above.	Brilliant deep red.	Fruity flavour. Clean and penetrating.
12	do.	do.			45	do.	Very deep	Fuller flavour. Clean and penetrating.
13	Red Gooseberry	1 gall. water + $\frac{1}{2}$ gall. syrup.	5 days	8 $\frac{1}{2}$	35	Pasteurised as above.	brilliant red	Distinct flavour, quite dis- similar from other fruits.
14	do.	do.			45	do.	red.	Definite fruit character.
15	do.	do.			60	—	do.	Somewhat similar to citrus types of syrup.
16	White Gooseberry	1 gall. water + $\frac{1}{2}$ gall. syrup.	5 days	8 $\frac{1}{2}$	35	Pasteurised as above.	Hazy.	Fuller. Definite fruit character.
17	do.	do.			48	do.	Clear : pale red.	Somewhat similar to citrus types of syrup.
18	do.	do.			60	—	do.	Clean but not characteristic of the fruit.
19	Wortleberry	1 gall. water + $\frac{1}{2}$ gall. syrup.	3 days	8	60	—	Hazy.	Very attractive.
20	Youngberry	1 gall. water + $\frac{1}{2}$ gall. syrup.	2 days	8 $\frac{1}{2}$	59	—	Brilliant : very dark red. Slightly hazy.	Sweet. As No. 17. Too sweet, but clean and pos- sibilities. sessing true fruit flavour. Very attractive. Remarkably fruity aroma and flavour.

(1) Total yield of juice in gallons per cwt. of fruit.

TABLE II.
DETAILS OF SYRUPS MADE IN THE 1935 SEASON. (Observations Made in February-March 1936)

No.	Fruit.	Additions per Cwt. of Crushed Fruit.	Macer- ation.	(1) Yield of Juice in galls.	Syrup.			Flavour.	Flavour of Diluted Syrup.
					Sugar Content %	Method of Preservation.	Appearance.		
1	Strawberry	Nil.	2 days	8	36	147 p.p.m. SO ₂ Pasteurised.	Slight haze.	Fruit flavour not marked.	Thin and lacking in character.
2	do.	do.			35		Clear.	Fuller flavour though not quite fresh.	Definitely fuller than No. 1.
3	do.	do.			45	183 p.p.m. SO ₂	As for No. 1	Fuller than No. 1. Decided fruit character.	Fresh and clean. Much more fruit character than No. 1.
4	do.	do.			45	Pasteurised.	As for No. 2	Characteristic fruit flavour. Clean and attractive.	Heavy flavour. Pleasant, but slightly "cooked."
5	Red Currant	½ gall. water.	2 days	8½	35	159 p.p.m. SO ₂	Brilliant.	Clean flavour. Not character- istic of fruit.	No definite flavour of fruit. Should be useful for blending.
6	do.	do.			35	Pasteurised.	do.	Fuller flavour.	Only very slight pasteurised taste.
7	do.	do.			45	172 p.p.m. SO ₂	do.	Similar to No. 5.	As No. 5.
8	Black Currant	Nil.	4 days	7	45	No treatment.	Clear.	Full and fruity. Best of series.	Very pleasant clean fruity aroma and flavour.
9	do.	do.			45	Pasteurised.	do.	Clean, but heavy, slightly "cooked" taste.	Pleasant but definitely less fresh than No. 8.
10	do.	do.			45	338 p.p.m. SO ₂	Brilliant.	Similar to No. 8, but very slight roughness on palate.	Full flavour. Very pleasant drink.
11	do.	do.			45	247 p.p.m. SO ₂	do.	do.	do.
12	do.	do.			45	193 p.p.m. SO ₂	do.	do.	do.
13	do.	do.			45	139 p.p.m. SO ₂	do.	do.	do.
14	do.	do.			45	51 p.p.m. SO ₂	do.	Similar to No. 9, but rough after-taste.	Full flavour. No "cooked" taste, but not so clean as No. 9.
15	Loganberry	Nil.	Nil.	7½	38	174 p.p.m. SO ₂	Hazy.	Fully flavoured and character- istic of fruit. Remarkably fresh and attractive aroma.	Full fresh fruit flavour. Very good beverage.
16	do.	do.			38	Pasteurised.	Brilliant.	Very similar to No. 15.	Very slight pasteurised taste.
17	do.	do.			46	139 p.p.m. SO ₂	Hazy.	Fuller than No. 15.	Otherwise as No. 15. Full, very brisk flavour, characteristic of loganberry.
18	do.	do.			45	Pasteurised.	As No. 16.	Similar to No. 15.	Best drink in the series.
19	do.	do.			45	No treatment.	Hazy.	Full and attractive flavour.	As No. 16. Slight fermented taste, but very fresh true fruit character.

(1) Total yield of juice in gallons per cwt. of fruit.

1. Additions to Crushed Fruit.

Earlier experiments had shown that the preliminary fermentation of the crushed fruit was more easily started in a medium possessing a higher sugar content than that of the fresh fruit and yet somewhat thinner in consistency than the thick pulp obtained by milling the fruit.

The bulk of fruit which is being treated is probably of importance ; for in the 1934 season, when the amounts were small, a suitable fermentation did not ensue until the crushed fruit had been diluted, whereas in the following year, when the fruit was treated in larger quantities, fermentation commenced immediately without any addition of water or syrup. There would appear to be no reason to treat the crushed fruit in any way previous to its maceration if large bulks are involved and the temperature of the juice is reasonably high.

2. Period of Maceration.

It has been the practice in these investigations before expressing the juice to leave the crushed fruit until a definite "head" has formed, indicating that appreciable fermentation has taken place. In one or two cases it has been noticed that where only very slight fermentation has occurred, the pulp has been most difficult to press, and the juice difficult to filter. Fermentation so slight as that has evidently been ineffective in decomposing the pectinous material, although materially adding to the viscosity of the juice and rendering difficult its expression and, later, its filtration to a brilliant condition. The same phenomenon has been noticed in the manufacture of unfermented apple juice. It is often easier to filter an absolutely fresh juice than one in which only very slight fermentation has occurred. The incidence of fermentation always results in the formation of a turbidity for which the yeast cells in suspension are largely responsible, and, if no considerable removal or change of pectin is effected, the juice is actually less easily filtered than in the fresh condition. Consequently, it is necessary to ensure that sufficient fermentation occurs to remove sufficient pectinous material. This stage is reached when the bulk of the crushed fruit becomes considerably thinner in consistency. The fermentation period should thus be prolonged until this is the case.

Three widely differing instances can be given to show how each lot of fruit must be given individual attention, and treated according to the conditions existing in each case.

In the first example, 2 cwts. of ripe black currants were milled,

complete with strigs, in the very hot weather of July, 1934. The pulped mass was semi-solid and quite impossible to stir. An attempt was made to express the juice from a portion of the pulp but, although an efficient hydraulic press was used, very little juice was obtained. The crushed fruit was then allowed to remain in a covered vat and fermentation commenced after 24 hours. A remarkable transformation occurred progressively in the mass of fruit, until after 6 days the crushed mass was quite liquid and could be stirred with ease. The pulp was pressed in a normal way and a good yield of juice with a deep red colour was obtained.

In the second case, a sample of 1 cwt. of low grade loganberries was purchased from a commercial plantation in Worcestershire. The fruit was ripe and was received in a very squashed condition, although no signs of bacterial or mould infection were noticeable. The mass was emptied into and crushed in a tub, and after 24 hours a vigorous fermentation was in progress. The pulp gave a remarkably good yield of juice and the residue left in the cloths was hard and dry.

Thirdly, a tub of Scottish grown raspberries was received in July, 1935, approximately 36 hours after the fruit had been picked. Many of the berries were completely disintegrated and a considerable volume of juice was present in the tub. Fermentation had already commenced and the condition of the fruit material was such that it was decided to press the whole bulk immediately. This was carried out with ease, and the resulting juice was fully flavoured and deep in colour.

It is probable that, whilst active fermentation is the primary agent in causing the various desirable changes in the pulp previous to expressing and filtering the juice, the mere fact of allowing the pulp to remain in contact with such juice as collects is of some importance.

The use of the term "maceration" in the fourth column in Tables I and II has been purposely adopted for this reason, for in cases where the fermentation is only slight, the maceration effects assume relatively greater importance. By analogy with the well-known method of maceration in cider-making, the process should be effective in providing a juice with a fuller aroma and flavour, and a deeper colour. This latter fact is of especial importance in the case of black currants. The juice obtained by pressing fresh fruit is pale pink in colour, and it is only as the result of maceration that the true fruit colour can be imparted to the juice.

The above considerations suggest that it is advisable as a regular

practice to allow the fruit to undergo some fermentation before pressing and filtering. The period necessary for this will vary with the condition and the quantity of the fruit, whilst the temperature of the crushed fruit material has an obvious significance in this connection. The reduction in consistency of the pulp and the appearance of visible signs of appreciable fermentation may be taken as signs that the juice may then be removed by pressure.

3. Yield of Juice.

The actual yields of juice (in gallons per cwt. of fruit) obtained in the two season's experiments, are tabulated below, the figures in brackets being the total yield (which includes any additions of water and syrup that may have been made to the crushed fruits).

				1934.	1935.
Strawberry	..	..	..	$7\frac{3}{4}$ (9)	8 (8)
Red Currant	..	..	..	$7\frac{3}{4}$ (9)	8 ($8\frac{1}{2}$)
Black Currant	..	..	..	6 ($7\frac{1}{2}$)	7 (7)
Loganberry	..	..	..	—	$7\frac{1}{2}$ ($7\frac{1}{2}$)
Raspberry	..	..	..	8 (8)	$8\frac{1}{4}$ ($8\frac{1}{4}$)
Red Gooseberry	..	..	..	7 ($8\frac{1}{2}$)	—
White Gooseberry	..	..	..	7 ($8\frac{1}{2}$)	—
Wortleberry	..	..	..	$6\frac{1}{2}$ (8)	7 (7)
Youngberry	..	..	..	$7\frac{1}{2}$ ($8\frac{1}{2}$)	—

These yields should be at least maintained under commercial procedure. In fact, since the press used in the experiments was a small hand-operated hydraulic machine higher yields may be expected with high-powered hydraulic presses, such as would be used in the factory.

4. Syrup Characters.

(a) *Sugar Content.*

The 1932 preliminary experiments were largely confined to the heavy type of syrup, in which 60-65% of sugar was sufficient to hold the product in a stable condition. A complete series of syrups made in this way in 1932 at Long Ashton still retain to a remarkable degree their fruit character, clarity and stability. One disadvantage, however, in using a syrup with such a high degree of sweetness is the very considerable dilution of fruit flavour and acidity which is caused both by the syruping process itself and by the subsequent dilution of the syrup necessary to reduce the sweetness to a suitable degree.

The reduction of the sweetness of a syrup has to be considered from two points of view. Firstly, the lower sugar-content syrups

will need to be stabilised either by pasteurisation or by the use of preservatives, and, secondly, the effect of the lower sugar content on retention of flavour is important.

Tables I and II contain some information on these two points. With regard to the pasteurisation of syrups, it has been shown that if this process is carried out at 165°F. for $\frac{1}{2}$ hour, complete control over fermentation is obtained, and little subsequent change takes place in the condition of the syrup. The process does not cause any immediate precipitation of fruit material, but cases have been noted where flocculent pectin deposits have formed in pasteurised syrups in which no biologically active material has been present. The effect of pasteurisation at this temperature is definitely noticeable to the expert taste. It is perhaps least noticeable in black currant, and most marked in strawberry. In view of the appeal which this latter fruit exerts on the public taste, the use of a cold preservation process with SO₂ was tried. Contradictory results were obtained in the 1935 season's experiments. In the case of strawberry, red currant and black currant syrups preserved with considerably less than half the maximum quantity of SO₂ permitted by law, the flavours had not been retained to the same extent as the pasteurised samples. The loganberry syrup (No. 15), however, was remarkably fresh in flavour, possessing the characteristic flavour of the fruit, and was quite as good as the pasteurised syrup. Sufficient data have not yet been accumulated to indicate the precise effect, if any, of SO₂ preservation on the fruit flavour proper; it would appear that the intensity of fruit flavour is not so great as in the pasteurised syrup, but the fresh fruit character is more marked. The data show that syrups can be effectively stabilised by SO₂.

The second point, namely the retention of fruit flavour in syrups with 30-45% sugar, is capable of more definite discussion. It has already been mentioned that the first series of syrups made at Long Ashton contained 60-65% sugar and that the flavours were retained to a remarkable extent four years later. The writer has recently tasted a similar series of syrups with 63% sugar, which were made 10 years ago and still possess the true flavour of the fruit. Tests made on lower sugar content syrups (30-45% sugar) show that the retention of flavour has not been so great as in the heavier syrups. This may be due to at least two causes. The additional processing, *i.e.* addition of SO₂ or pasteurisation, may have adversely affected the flavour or, alternatively, the low sugar content may not have been sufficient to retain the aroma and flavour of the fruit.

Whatever the actual reason may be, it is definite that the low sugar syrups which have to be subjected to further processing beyond the mixing of filtered juice with sugar, are not so stable from a flavour standpoint as those with higher sugar percentages which have not received any further treatment.

(b) *Acidity of Syrup.*

The palatability of the earlier series of syrups suffered on account of the low acidity in the finished beverages. The acidity of the product, being the factor responsible for the briskness of the beverage and thus responsible to a large extent for the thirst-quenching and attractive features of the diluted syrup, is most important. A survey of a representative series of citrus and other beverages of both cordial and syrup types, has been carried out at Long Ashton, and the following data have been calculated from the results.

Average acidity (as citric acid) for 17 citrus products					= 1.82%	
"	"	"	"	"	19 non-citrus products	= 0.84%
"	"	"	"	"	21 citrus squashes	= 1.82%

The acidities of the English soft fruits are very much lower than those of the orange and lemon, and whilst insufficient data have yet been accumulated to give accurate limits, the acidities of the juices that have been found in the last few seasons' experiments are as follows:—

Green Gooseberry	..	..	..	..	1.3 — 2.9%
Strawberry	..	..	..	..	0.7 — 1.3%
Raspberry	..	..	..	..	1.5 — 2.5%
Loganberry	..	..	..	..	2.0 — 3.0%
Red Currant	..	..	..	..	1.8 — 2.8%
Black Currant	..	..	..	..	1.5 — 3.0%
Blackberry	..	..	..	..	1.2 — 1.8%

The syrups made from these juices will vary in acidity according to the amount of sugar added. For example, a fresh juice with 2.0% of acidity would be converted into a heavy syrup with 1.0% acidity which, on dilution with water, would result in a beverage with about 0.2% of acidity. This is a low figure for a summer drink, which should contain at least 0.4-0.6% acid. The implication is that heavy syrups made from the English berry fruits will need the addition of some acid to rectify the deficiency of the fruit in this constituent. The quantity of acid to be added will naturally depend on the acidity of the fresh juice, and the degree of dilution suggested for the syrup, but the final acidity should be between the limits of 1.5-2.0% for syrups with 55% sugar or more. Most

difficulty will be experienced with the strawberry, for many juices of this fruit with acidities well below 1% have been noted.

It should be emphasised that the above considerations do not apply to the production of syrups for use with milk.

(c) *Method of Preservation.*

Reference has already been made to this in the previous Section 4. The use of SO_2 in the amounts given in the eighth column of Table II was effective in preventing any trace of fermentation, except in the case of Nos. 15 and 17, in which cases there was slight evolution of gas. The maximum legal amount of SO_2 in syrups is 350 parts per million. The haze or deposit which formed in the samples preserved by SO_2 or pasteurisation was largely chemical in origin.

(d) *Appearance and Deposit.*

The stirring-in of solid cane sugar to the clear filtered fresh juice did not impair its clarity, and except in certain cases, such as Nos. 1, 3, 4, 15, 17, and 19, the syrups were brilliantly clear after at least 12 months' storage. The use of SO_2 affects the colour to a marked degree; even with the small amounts used the natural colours were almost completely bleached. Water-soluble colours have been used with success to standardise the colour. The dyes are used as solutions containing $\frac{1}{2}$ oz. per pint, and in general, $\frac{1}{4}$ pint of solution per 100 lb. of syrup was used.

(e) *Flavour of Syrups and Diluted^{*} Beverages.*

The remarks tabulated in the last two columns of Tables I and II are sufficient to indicate the salient features of the flavours both of the syrups themselves and of the diluted drinks.

It is only necessary to draw attention to three points of interest. In the case of Nos. 8 and 19 (Table II) no preservation treatment whatever had been adopted; and the syrups, although nearly 12 months old, were in good condition and possessed very full and attractive flavours.

In the second place, the use of liquid glucose as a sweetening agent cannot be recommended on the results of the four experiments, Nos. 7-10 (Table I).

Finally, the syrups that offered the best possibility for commercial production for the purpose of producing beverages by dilution with water or soda water, were the following :—

Table I: Black Currant (No. 12), Red Gooseberry (No. 14), and White Gooseberry (No. 17).

Table II: Strawberry (Nos. 3 and 4), Black Currant (Nos. 10-13), Loganberry (Nos. 15-18).

General Recommendations for Manufacture of Fruit Syrups.

The following recommendations apply to the general methods of manufacture of fruit syrups for general purposes. Special precautions which are necessary when syrups are being produced specifically for use in milk are given in the second part of this article.

Treatment of Fruit.

The fruit should be reasonably clean and free from earth or extraneous matter. Whilst undersized, misshapen or badly squashed fruit are quite satisfactory for products manufacture, it is essential that no appreciable mould or bacterial infection should be present in the fruit.

The usual grater type of mill has been used with success at Long Ashton to disintegrate the fruit. The mill revolves at 2,000 r.p.m. and delivers a fine pulp of fruit tissue and juice. The setting of the knives is a matter of experience but with even a coarse set, an efficient disruption of the berries is effected.

Cherries present a somewhat different problem from the soft berry fruits. Although cherries have not yet been included in the Long Ashton programme, some information may be given here on the American methods of extracting the juice (1). The fruits are washed and shredded into a coarse pulp by mechanical means, and the juice expressed in the usual way. It is recommended to heat the pulp to 190—200°F. to inactivate the enzymes and micro-organisms in the pulp which would tend to produce "off" flavours later in the storage of the syrup.

Maceration.

The disintegrated fruit should be allowed to stand in suitably sized vats until the texture of the mass has become appreciably thinner and definite signs of fermentation are visible. A warm atmosphere is advisable for this process. With large bulks of fruit this treatment should be completed in 2—4 days. No uniformity of behaviour has been discovered in the bulks of fermenting fruit; thus in some cases the more solid portions of the tissue rise to the surface, leaving a liquid media beneath, and, less frequently, the reverse is the case.

Expressing the Juice.

It is necessary to use a highly-powered hydraulic press which will give a total pressure of 200 tons for this purpose. The machine is similar to the standard type in use for cider-making. The pulp is received in large cotton cloths, each resting on a wooden rack to provide stability and to facilitate the draining away of the juice from the vertical series of racks and cloths which is technically known as a "cheese." It is most important that the pulp which is placed in the cloths should not be too liquid, or an unstable form of cheese will be built. This will inevitably lead to difficulties in the pressing manipulations and result in a poor yield of juice. If there is any separation of pulp and juice during maceration or fermentation, the more liquid portions should be drained away and not placed in the press cloths.

Clarification of the Juice.

Experience with the pressing of soft fruit has indicated that, when compared with the apple, the juices are much thicker and contain relatively high amounts of finely divided tissue. The sedimentation method of removing this material may not be effective if any considerable fermentation is in progress as the evolution of gas will disturb the deposit and distribute the material throughout the bulk of the juice. On the other hand, if the onset of fermentation is slow and there is no active evolution of gas during the first few days the greater part of the tissue material will settle out on standing and this will considerably relieve the filter.

A much more certain method is to pass the juice as it runs from the press through a supercentrifuge. This effectively removes all the solid portions of the tissue and has been proved to be a most valuable aid to filtration in the cider industry (2) (3) (4). Its effectiveness should be even more marked in the treatment of other fruit juices.

Enzyme clarification has been studied at Long Ashton and two reports on the investigations have been published (5) (6). With juices that are very difficult to clear, it may be economical to treat the material with an enzyme which will decompose either the pectinous or the nitrogenous compounds.

The juice, treated by the centrifuge or by sedimentation, is then filtered to a clear condition. If the previous processes have been effective, one passage through the filter should suffice.

In the experiments at Long Ashton two types of filter have been used. The first, a pulp filter, similar to the usual type found in

cider factories, has proved satisfactory with all juices. The pulp, however, has to be thoroughly cleaned between each filtration and a special washer with a rotary beater must be used. The second type is the plate and frame filter in which a layer of filter-aid (calcined diatomaceous earth) is laid down on cloths stretched over wooden frames. The filter-aid is discarded after one operation. One advantage possessed by this type of filter over the pulp filters is the very small amount of liquid held by the filtering medium and the consequent saving in time and expense in obtaining a true sample. The plate and frame filter has been also used at Long Ashton on two occasions with heavy syrups containing 65% sugar. Clarification was excellent and the rate of filtration was satisfactory.

Syruping.

The juice should be kept at as low a temperature as possible to avoid any fermentation and consequent clouding of the juice, and should be converted into a syrup with the least possible delay. The sugar should be stirred in without heat, and any further treatment to be given to the product at this stage depends on the concentration of sugar that is being employed. With a well clarified juice, and working under conditions of strict cleanliness of premises, utensils and bottles, a syrup with 60% of sugar should prove to be stable over a considerable period. Any reduction in sugar content should be accompanied either by pasteurisation or by the use of SO_2 or sodium benzoate.

The experiments carried out at Long Ashton have included the use of cane sugar and liquid glucose only. No difficulty has been experienced with crystallisation in the heavy syrups, but the incorporation of a certain proportion of invert sugar with the cane sugar would preclude the possibility of any solid formation from this source.

It is necessary to add that the sole reason for adding such high amounts of sugar is to provide a suitable soluble solids content as a safeguard against fermentation. It is possible that other sugars with less sweetness than cane sugar may be suitable to provide this safeguard with the added advantage of not imparting such a sweet taste to the syrup. Trials along these lines are at present in progress.

Information on the various types of machines mentioned in this paper can be obtained from the writer at Long Ashton.

B. USE OF PURE FRUIT SYRUPS IN MILK BEVERAGES.

During the past twelve months this country has seen the commencement of an attempt of national and far-reaching importance by the Milk Marketing Board to increase the consumption of milk in a fresh state. Prominent amongst the methods which are being adopted to effect this is the establishment of a chain of milk bars throughout the country. These bars, although actually owned by private enterprise, are being run in close association with the Marketing Officers of the Milk Marketing Board. If the success of the bars already serving milk drinks can be taken as an augury for the future, it would appear that a very considerable quantity of milk will be consumed in this way.

Amongst the flavourings used to produce "milk shakes" are some of the English fruits such as strawberry and raspberry. The writer, after some experience at milk bars in London and in the provinces, as well as at demonstration bars conducted by the National Milk Publicity Council, felt that there should be an outlet for fruit syrups as made at Long Ashton through the agency of such bars. Consequently, a few milk shakes were prepared and, later, the Regional Officer of the Milk Publicity Council was invited to discuss the products. Satisfactory shakes were prepared, but the fresh fruit season being over, it was not possible to make up any syrups according to a recipe which was suggested by the results of the preliminary tests. Consequently the data which are given later in this paper were obtained with syrups which did not possess the ideal composition for blending with milk; but, in view of the very rapid developments expected to take place during the summer season of 1936, it is felt desirable to present without delay the results so far obtained although the investigations have not been completed.

Four main considerations arise when pure fruit juices are to be blended with milk for the production of milk shakes, viz. curdling, acidity, sweetness, and true fruit flavour.

Curdling. With regard to curdling, this is due to the coagulation of the casein in the milk. It appears that this phenomenon is intimately related to the pH of the milk: for coagulation in pure milk commences when the pH is 5.5 and is completed at a pH of 4.7. The acidity of the milk increases as the pH figure decreases, and it is thus obvious that the progressive addition of a fruit syrup containing natural or added acids to milk will first cause a slight precipitation of casein, and later complete coagulation with resultant

separation into curds and whey. The quantitative effects of this acid addition are given in Table III and are alluded to in the later discussion of these data.

Acidity. The acidity of the syrup is of twofold importance. Its effect on curdling has been mentioned above, but there is an important bearing on the ultimate flavour of the milk shake that must be borne in mind. Fruit syrups are apt to taste very sweet and cloying unless the acidity is such that a certain degree of briskness is imparted to the product. This acidity also appears to bring the characteristic fruit flavour into greater prominence in the syrup or any diluted beverage that may be produced. Consequently, a definite degree of acidity in the syrup is necessary to give the required briskness and flavour, but the curdling problem places a definite limit on the actual amount that can safely be present. Curdling appears to be more accurately correlated with pH than with titratable acidity, and it is doubtful whether any useful relationship involving curdling and the latter factor will be easily discovered.

Sweetness. The third factor, sweetness, is merely concerned with the sugar content of the syrup necessary to impart a sufficient but not excessive sweetness to the milk product. The amount of syrup that will normally be added to the milk will be largely determined by the intensity of fruit flavour in the milk-fruit syrup mixture.

Fruit Flavour. This last point introduces the fourth consideration which is of vital importance. It has been determined that the most attractive milk shake is one which combines the flavours of milk and fruit without either flavour being predominant. If very intense fruit flavourings are introduced, the milk character is overwhelmed and the flavour of the mixed beverage is unbalanced. It is important to ensure that the sugar content of the syrup is such that sufficient syrup can be added to the milk to give a satisfactory fruit flavour without at the same time producing too sweet a beverage.

The above considerations show that the three qualifications needed for a fruit syrup to be satisfactory for the manufacture of milk shakes are :—

- (1) The acidity should be sufficiently high to give character to the beverage, and yet not high enough to curdle the milk
- (2) The sugar content should not be high enough to impart an excessive sweetness to the milk shake when the syrup and milk are used in normal proportions.
- (3) The characteristic fruit flavour should be suitably intense in the milk shake without masking the flavour of the milk.

With these features in mind, the following tests were carried out on a series of syrups made at Long Ashton, together with samples from three commercial firms, who had made small bulks of syrups according to recommendations supplied by Long Ashton, and several commercial syrups as used in milk bars. Sugar content, acidity (as citric acid by weight), and pH were first determined on the syrups themselves. Various mixtures of milk and syrups were then prepared, and the latter two determinations repeated. The tests were carried out at 15–17°C., and the milk and syrup mixed in an electrically-driven machine. The pH was determined by the quinhydrone electrode method and the sugar content derived from the specific gravity by means of suitable tables.

Table III contains all the relevant data obtained during these tests. The remarks on the flavour of the milk shakes were collected on a number of occasions when a wide variety of visitors, including many experts from milk and syrup firms, tasted the shakes from a critical point of view. The tabulated observations have been chosen to represent as accurately as possible the general consensus of opinion.

Discussion of Results.

Sugar Content.

The four syrups which were obtained from sources actually supplying Milk Bars, Nos. 6, 13, 22, and 35, had sugar contents of 65, 52, 52, and 60% respectively. None of these was too sweet in milk when added in a 1:5 proportion, although pure fruit syrups with 60% and over of sugar were regarded as too sweet.

Whilst 45% sugar syrups would appear to be of the right order of sweetness, it should be noted that no pure fruit syrups made at Long Ashton with sugar contents between 45% and 60% were tasted, and it is possible that with cane sugar syrups 50 or 55% may not be too high a sugar content.

Acidity and pH.

There is little correlation between the pH and titratable acidity of the various syrups. Many anomalies can be found, but the most striking is the case of samples 36 and 37, where identical values for pH are accompanied by acidities of 5.50% and 28.17%. Different acids or buffering agents may be present in the orange and lemon concentrates to account for this remarkable observation. A further point of interest is to be found in the variations of pH and

TABLE III.
ANALYTICAL DATA ON FRUIT SYRUPS AND MILK SHAKES.
* Indicates Pasteurisation.

No.	Fruit.	Origin of Syrup.	Special Features.	Sugar per cent.	pH of Syrup.	Citric Acid per cent.	Milk-syrup Mixtures				Remarks on Flavour of Milk Syrup Mixture.
							Proportion of Milk to Syrup.	pH	Acidity (as Citric Acid) per cent.	Curdling Test.	
1	Strawberry	Long Ashton	Made in 1932	66	5.85	0.44	100:20	5.52	0.13	—(No Curdling)	Too sweet: full fruity flavour.
2	do.	Commercial (pure fruit syrup).	do. 1935	64	4.56	0.39	100:20	6.30	0.07	—	Too sweet: fruity flavour but not strong. Fresher flavour than No. 1.
3	do.	do	do. do.	44	4.66	0.44	100:20	6.15	0.12	—	Correct sweetness. Fruity flavour.
4	do.	Long Ashton	do. 1934	45	4.91	2.31	100:30 100:5 100:10 100:15	5.90 6.16 5.54	0.15 0.16 0.24	— — — +(Curdled)	Too sweet. Very weak fruit flavour. Pleasant taste, true to Strawberry.
5	do.	Commercial (pure fruit syrup).	do. 1935	37	3.47	0.97	100:20	5.92	0.13	—	Correct sweetness: full flavour, but definitely "cooked."
6	do.	Commercial (fruit juice concentrate)	Concentrated juice. (Very "cooked" taste.)	65	3.13	0.81	100:30 100:20 100:40	5.52 5.78 5.21	0.20 0.17 0.26	— — —	Correct sweetness: full flavour, but very definitely "cooked." Too sweet and much too heavy a fruit flavour.
7	Raspberry	Long Ashton	Made in 1932	66	4.18	0.76	100:20 100:30	5.71 5.29	0.17 0.23	— Barely +	Too sweet: distinct Raspberry flavour.
8	do.	Commercial (pure fruit syrup).	do. 1935	64	4.41	0.71	100:20	5.77	0.13	—	Too sweet: characteristic fruit taste: very good. Full fruit flavour.
9	do.	do.	do. do.	44	3.58	1.09	100:20 100:30	5.46 5.07	0.24 0.28	— —	Fresh flavour: Not intense Ditto.
10	do.	Long Ashton	do. do.	60	5.49	1.14	100:10 100:20	6.02 5.95	0.10 0.17	— —	Ditto.
11	do.	do. 0.01% SO ₂ present.	do. do.	45	3.15	1.42	100:20 100:25	5.14 4.88	0.27 0.30	— Barely +	Ditto.

TABLE III.—*continued.*
ANALYTICAL DATA ON FRUIT SYRUPS AND MILK SHAKES.

* Indicates Pasteurisation.

No.	Fruit.	Origin of Syrup.	Special Features.	Sugar per cent.	pH of Syrup.	Citric Acid per cent.	Milk-syrup Mixtures.				Remarks on Flavour of Milk Syrup Mixture.
							Proportion of Milk to Syrup.	pH	Acidity (as Citric Acid) per cent.	Curdling Test.	
12	Raspberry	Commercial .. (pure fruit syrup).	Made in 1926	64	3.89	0.49	100:20			—	Similar to No. 7 but flavour not so intense or fresh.
13	do.	Commercial milk syrup (contains essences).	Flavour no resemblance to raspberry. Very pungent.	52	3.77	0.32	100:20	6.48	0.06	—	Full flavour, but no resemblance to fruit. Severely criticised by many, on account of its "fruit drop" character.
14	Loganberry	Long Ashton ..	Made in 1932	66	3.87	1.10	100:20		0.25	—	Too sweet : fruity flavour but not intense or characteristic of fruit.
15	do.	Commercial .. (pure fruit syrup).	do. 1935	64	4.16	0.98	100:30		0.26	Barely +	
16	do.	do.	do. do.	44	3.51	1.41	100:20		0.15	—	Too sweet : excellent fruit flavour with unique aroma : distinct acid flavour. Correct sweetness : good flavour.
17	do.	do.	do. do.	45	3.32	1.57	100:30		0.36	+	Correct sweetness : poor flavour.
18	do.	Long Ashton .. (citric acid added).	do. do.	35	3.10	2.59	100:10		0.28	—	Much too acid.
19	do.	Commercial .. (pure fruit syrup).	do. 1926	64	3.14	0.98	100:15		0.29	+	
20	Black Currant	Long Ashton ..	Made in 1932	65	4.80	1.61	100:20			—	Fruity and pleasant. Not characteristic of the fruit.
21	do.	Commercial .. (pure fruit syrup).	do. 1935	41	5.01	2.25	100:20			—	Slightly too sweet : full black currant flavour, very good.
22	do.	Commercial milk syrup (contains essences).	Very pungent flavour. No resemblance to black currant.	52	3.38	0.43	100:20		0.37	—	Fair.
								4.80	0.14	—	Full flavour, which whilst not unpleasant, bore no resemblance whatever to the fruit.

TABLE III.—*continued.*
ANALYTICAL DATA ON FRUIT SYRUPS AND MILK SHAKES.

* Indicates Pasteurisation.

No.	Fruit.	Origin of Syrup.	Special Features.	Sugar per cent.	pH of Syrup.	Citric Acid per cent.	Milk-syrup Mixtures.				
							Proportion of Milk to Syrup.	pH	Acidity (as Citric Acid) per cent.	Curdling Test.	Remarks on Flavour of Milk Syrup Mixture.
23	Black Currant	Commercial (pure fruit-syrup).	Made in 1926	62	4.50	1.09	100:20			—	Remarkably full black currant flavour which was immediately recognisable as such.
24	Gooseberry *	do.	Made in 1935	44	5.28	0.98	100:20	5.67	0.17	—	Correct sweetness : fruity but not true to fruit used.
25	Plum *	do.	Made in 1935	44	3.56	0.70	100:20 100:30	5.82 5.63	0.23 0.24	—	Too sweet : poor.
26	Wortleberry ..	Long Ashton ..	Made in 1934	60	3.76	0.49	100:20	6.12	0.11	—	Character of its own : full clean flavour of the fruit which was highly praised.
27	do. *	Commercial (pure fruit syrup).	Made in 1935	42	3.10	0.86	100:20 100:30	5.78 5.46	0.14 0.18	—	Weak flavour. Intense colour.
28	Blackberry ..	do.	Made in 1935	64	3.84	0.60	100:20	5.90	0.11	—	Too sweet : pleasant fruity flavour, although not reminiscent of fruit.
29	do. *	do.	do. do.	44	3.68	0.92	100:20	5.65	0.19	—	Correct sweetness : pleasant flavour.
30	do. *	do.	do. do.	35	3.54	0.69	100:40 100:20 100:30	5.01 6.04 5.77	0.28 0.10 0.10	Barely + — —	Too sweet. Fair.
31	Strawberry ..	Commercial ..	Made with concentrate and synthetic flavouring.	62	3.17	0.81	100:20	5.48	0.17	—	Correct sweetness, but true strawberry flavour not prominent. Pleasant drink.

TABLE III.—*continued.*
ANALYTICAL DATA ON FRUIT SYRUPS AND MILK SHAKES.
* Indicates Pasteurisation.

No.	Fruit.	Origin of Syrup.	Special Features.	Sugar per cent.	pH of Syrup.	Citric Acid per cent.	Milk-syrup Mixtures.				Remarks on Flavour of Milk Syrup Mixture.
							Proportion of Milk to Syrup.	pH	Acidity (as Citric Acid) per cent.	Curdling Test.	
32	Raspberry	Commercial	Made with concentrate and synthetic flavouring.	62	2.82	1.09	100:20	5.32	0.16	—	Correct sweetness, full flavour, but not quite true to fruit.
33	Lemon	do.	Made with natural products, do.	60	2.84	1.20	100:20	5.15	0.17	—	Excellent.
34	Orange	do.		63	4.55	1.10	100:20	5.50	0.19	—	Not so full or fresh in flavour as No. 33.
35	Pineapple	Commercial milk syrup	—	60	2.58	2.02	100:10	5.46	0.23	—	Correct sweetness. Artificial taste, with unattractive flavour.
36	Orange Concentrate, do.	Commercial (pure syrup),	Added simple syrup 5:1	74	5.04	5.50	100:20 100:20	4.22	1.33	Barely +	Too intense flavour and too acid. Fair.
37	Lemon Concentrate, do.	do.	do. 3:1	42	5.04	28.17	100:20 100:5 100:10	3.63	1.38	Barely +	Too strong a flavour. Rather rough taste. Undrinkable. Too acid.
38	Canned Orange juice, do.	do.	do. 5:1 do. 3:1 do. 3:1	12	4.01	1.01	100:10 100:20 100:20	5.61	0.18	+ — —	Deficient in lemon flavour. Still too acid. Curdled. No taste of orange. Poor. do.

acidity in the four samples especially mentioned above. The pH values for samples 6, 13, 22 and 35, all of these syrups being sold for use with milk, were 3.13, 3.77, 3.38 and 2.58, whilst the acidities were 0.81, 0.32, 0.43, and 2.02%. When the acidities are compared with those of pure fruit syrups in the Table it will be seen that the pH figures are rather low, indicating the possible presence of a stronger acid than citric acid.

The only syrups that curdled milk when added to it in 1:5 proportion were Nos. 4 (Long Ashton strawberry, to which citric acid had been added) and No. 18 (Long Ashton loganberry, similarly treated). The pH data for the two syrups were 4.91 and 3.10, whilst the acidities were 2.31 and 2.59% of citric acid. It is quite clear that with all the fruit syrups made from English fruit included in the experiments, no danger of curdling need be feared if no acid material is added to the syrup and the 1:5 ratio of syrup to milk is not exceeded.

The pH data on the milk shakes show that the lowest values for the pH of the shakes at which coagulation does not occur are 5.07, 4.88 and 4.80 (Nos. 9, 11 and 21). The total acidities of the same mixtures were 0.28, 0.30 and 0.37% respectively.

The acidities of the syrups from which these milk-fruit mixtures were made were 1.09, 1.42 and 2.25% citric acid.

The acidity is naturally higher, and the pH lower, in syrups with lower sugar contents, for more juice and less sugar is used in their production. Hence, with the more acid fruits, such as loganberry and black currant, it is desirable to make syrups with at least 50% of sugar.

Flavour.

There is no possible doubt that the general consensus of opinion is that the pure fruit syrups are preferable in flavour to some of the other types of syrup which have been tasted. It must be admitted, however, that the intensity of the fruit flavour is sometimes rather weaker in the pure syrup than is desired, but this is generally the case only in the heavy syrups where the excessive sweetness masks the true flavour of the fruit. It is interesting to note that, despite its age and high sugar content, the syrup No. 12, produced according to Long Ashton directions in 1926, gave the fullest and most pleasant fruit flavoured milk shake of the series.

Two of the existing commercial products, Nos. 13 and 22, were characterised by very pungent aromas and flavours. These were not unpleasant and imparted a pleasing taste to the milk. There

was always the danger, however, of the milk character being completely lost in the penetrating "perfume" smell and taste. In neither case did the product bear the slightest resemblance whatever to the fruit under whose name the syrup was sold.

General.

The tests show that pure fruit syrups can be satisfactorily combined with milk to form milk shakes. The outstanding points are to avoid the use of too heavy syrups and the addition of any acid to the syrup. In most cases with the home-grown fruit included in the tests it has been possible to obtain syrups that have not curdled the milk and have imparted a pleasant, characteristic fruit taste to the milk shake.

SUMMARY.

- A. 1. The detailed results of two season's experiments on the production of syrups from English berry fruits are given, and the various points discussed.
2. It is indicated that attractive syrups have been made from strawberries, loganberries, black currants, and red and white gooseberries.
3. Details for the commercial manufacture of fruit syrups are discussed in the light of the experimental results, and recommendations are given.
- B. 1. The possibility of utilising pure fruit syrups in milk is discussed, and the various features essential in such syrups are enumerated.
2. A series of experiments are described in which fruit syrups from various sources have been analysed before and after their incorporation in milk. The tests indicate that if no acid is added to the pure fruit syrup, and if the syrup is added to the milk in proportion of 1:5 of syrup to milk, there is no danger of curdling taking place.

The pH of the mixture which appears to be safe from the curdling point of view is about 5.0.

3. Pure fruit syrups impart the characteristic flavour of the fruit to the milk shake. It is essential to avoid an excessively sweet syrup, and a sugar content of 45—55% appears to be ideal.

ACKNOWLEDGMENT.

The author wishes to record the valuable help of Mr. N. P. Bridgewater, B.Sc., who carried out the pH and acidity determinations given in the second part of this paper.

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INVESTIGATIONS ON FRUIT PRODUCTS.

VII.—PRODUCTION OF FRUIT SQUASHES.

PROGRESS REPORT.

By VERNON L. S. CHARLEY.

The investigations which have previously appeared in this series were concerned solely with filtered products, in the manufacture of which the fruit tissues are discarded when once the juice has been expressed. But the very definite aroma of apples that can be noticed near any bulk of freshly pressed apple pomace is a constant reminder of the impossibility of removing all the flavouring and aromatic constituents of the apple from the press cake, and when other possible products from soft fruit were under consideration, it was thought probable that "cloudy" syrups which were not filtered but which contained certain of the fruit tissues would retain more of the characteristic fruit flavour than filtered syrups of the cordial type.

The citrus products industry has developed a series of squashes which have experienced a remarkable vogue in recent years. Lemon, orange and lime products, established favourites a few years ago, have been followed by grape fruit and passion fruit squashes. Considering the squash and syrup industry in a wide sense, it has become increasingly apparent that products manufactured solely from foreign raw material were supplying most of the demand for this type of drink.

In view of this situation, some preliminary experiments on squashes were carried out in the late summer of 1934. The products then obtained were pleasingly attractive in flavour and aroma, and the chief difficulty was concerned with the mechanical processing needed to produce a satisfactory appearance and texture in the squash. This matter was given special attention during the summer of 1935. Some progress was made with the manipulative side of the work, but owing to the inauspicious weather conditions the products did not reach the high standard of the previous season. Consequently this progress report is intended solely to give an account of work which has so far been attempted, and not to suggest that the various problems involved in the manufacture of squashes from soft fruits have yet been satisfactorily solved.

Squashes from citrus fruits are usually made up in this country from imported cloudy citrus juices, which are usually heavily sulphured for preservation purposes, and are later sweetened with boiled sugar syrups to a specific gravity of 1.170, which is equivalent to 40% sugar content. The preservative is supplied by the addition of sulphur dioxide (in the form of solid potassium metabisulphite). Although the effect of this on the pale colours of citrus products is not of vital importance, the position is decidedly otherwise where the red shades and other colours of the English soft fruits are concerned. The main difference between citrus and soft berry fruits is, however, not concerned with colour. The two types of fruits vary in fundamental respects in the nature of their tissues. The pale compact laminae which form the bulk of the lemon and grape fruit tissues are pleasing in appearance, and when of suitable size separate into two layers leaving an intermediate layer of cloudy liquor. But the tissue from strawberries, raspberries, black currants, etc., bears no resemblance to that from citrus fruit. No definite structure is apparent, and the tissue tends to collect on the bottom of the bottle as a sludge of flocculent material. In some cases separation into layers occurs but, in general, some tissue remains dispersed throughout the liquid. In the case of black currants, the occasional occurrence of clots of jelly appeared to improve the clarity of the intermediate juice—probably mainly because of the removal of pectin from colloidal solution.

These distinguishing features are due to fundamental differences in the size and structure of the fruit cells. In the case of citrus fruits the cells are extremely large, being readily seen by the naked eye, in the case of Jaffa oranges reaching a size of $\frac{1}{2}$ in. by $\frac{1}{8}$ in. in many cases. These cells possess very thin cell walls comprised almost entirely of cellulose with no associated pectin. On the other hand, berry fruits consist of very small cells, for the observation of which microscopic aid is essential. The cell walls are considerably thickened by the deposition of pectinous and other substances and consequently the cell wall is very thick by comparison with the cell size. The characteristic fragments of fruit tissue in citrus squashes may be composed of only a few cells, whereas owing to the pulping process needed to remove undesirable tissues, the corresponding material in the case of the berry fruits is an amorphous sludge of very minute cells.

The following account of the experiments carried out in the last two seasons indicates the progress that has been made in overcoming some of the difficulties in the preparation of squashes from berry fruits and the problems that are still awaiting solution.

EXPERIMENTAL.

Apparatus and Material.

The machine used for pulping the fruit was similar to a mincer but with one important difference. The continuous screw rotated inside a barrel which was perforated throughout with holes, 1/16 in. in diameter and spaced so that there were 80 holes per square inch. The end of the cylinder remote from the handle and fruit entrance was almost closed by a blunt end fixed to the moving screw and, by means of an adjustment, this could be so arranged as to leave a gap of suitable size for the seeds, etc., to be forced through. If the outlet was small, the pressure inside the perforated cylinder was increased and the harder portions of tissue, including the seeds, were forced through the perforations with the juice and finer tissues. On the other hand, if the outlet was increased in size, the seeds and skins were easily forced through the outlet, and the perforations only allowed a few seeds to pass through. The primary difficulty was to arrive at the optimum dimensions for the cylindrical sieve in the inside of which the continuous screw rotated. Very small perforations certainly excluded the seeds, but they also prevented much of the finer tissues passing through. This material was then discarded at the outlet for the residual pulp. In the other case, a much larger sieve permitted very little waste, but allowed most of the seeds to pass through with the juice.

The sugar used in making the squashes was in the form of water-white, boiled, cane sugar (Mineral Water A) syrup with either 45 or 60% sugar. Citric acid was added as a concentrated solution (1 lb. crystals dissolved in 1 pint water). The colouring materials were water soluble dyes (strength : $\frac{1}{2}$ oz. per pint of water).

The squashes were stored in the usual type of 28 oz. white glass bottles or in glass gallon jars with screw caps fitted with an interior layer of cork and wax cover.

For convenience, the results of the two seasons experimental work are dealt with in separate sections.

Experiments in 1934.

Strawberry.

A sample of poor quality berries was used for squash production. The fruits were hulled and after decomposed and green specimens had been discarded, the sound berries were passed through the pulping machine. Whilst a large number of seeds came through the sieve, the majority were retained in a thick layer of tissue

that formed on the outer surface of the perforated cylinder, and only a few actually gained access to the juice. The residue passing from the outlet was a thick slimy mass of hard tissues mixed with the greater part of the seeds.

The pulp was immediately mixed with sugar syrup, citric acid added to taste, and sufficient potassium metabisulphite (dissolved in a small volume of water) added to check fermentation.

The tissue of this squash formed two definite layers and the intermediate liquid was brilliantly clear. It was found to be most difficult to remove the last traces of seeds from the squash on account of the long "tail" of fleshy tissue which was attached to each seed. Eventually, the whole squash was poured through a fine sieve and the tissue that was left behind was gently rubbed through with a pestle until only seeds were left. By this means, a product with only five or six seeds per pint bottle was produced. The general appearance, though not so attractive as a citrus squash, was by no means discouraging.

The flavour was extremely good. The aroma and flavour of the fresh fruit were fully retained, and remained so until eighteen months after manufacture, when the stock of samples was exhausted. The squash was tasted by a variety of visitors, many with technical qualifications in the beverage industry, and it was agreed that such a product possessed decided commercial possibilities.

Raspberry.

Considerable difficulty was encountered in obtaining a seedless pulp. The residue was sieved twice and although the final product was not entirely free from seeds, the number was limited to five or six per 28 oz. bottle.

The flavours of the various squashes were full and characteristic of the fruit. Whilst lacking the delicacy of the strawberry products, the flavours of the raspberry squashes were remarkably penetrating.

An instance of discolouration due to metallic contamination occurred in one of the experimental squashes. The true red colour changed to an unpleasant purple-red, and although only a small amount of pulp was actually left in the machine for half an hour, this was effective, when added to a bulk of squash, in destroying the natural colour of a large quantity of pulp.

Black Currant.

This presented rather less difficulty in preparation than the preceding squashes and the residue consisted very largely of skins and seeds.

The colour was rather unattractive. This is undoubtedly due to the fact that the characteristic colour of black currants is entirely in the skins, and the viscous juice is only pale pink in colour. Similar effects have been noticed in fruit syrup production, where it is necessary to allow the skins to macerate for several days in the juice to effect some transference of colour from the skins to the juice. After a lapse of several months the colour was only pale pink, but, as will be seen in the next section, this defect can be overcome by the use of a colouring agent permitted under the Ministry of Health regulations.

The texture of the squash was quite dissimilar from that of the strawberry or raspberry. Despite the considerable attenuation caused by the addition of the syrup, the mixture possessed a "gluey" consistency which detrimentally affected the pouring-out quality of the squash. It is possible that a slight fermentation in the pulp may have a thinning action on the juice but this has not yet been studied.

The flavour was very satisfactory. The viscosity of the squash was no detriment, and the diluted product possessed a soft, mellow, fully characteristic flavour of black currant fruit. In this case, as in the two preceding squashes, the flavour was retained until at least eighteen months after manufacture.

General.

The samples prepared were most encouraging from the point of view of flavour, but the texture and appearance of the products in most cases left much to be desired. The outstanding flavour was that of the strawberry, which was characteristic of the fruit and extremely delicate in aroma.

Experiments in 1935.

Strawberry, No. 1.

A quantity of berries, of the Oberschlesien variety, in good condition, were hulled and pulped. The machine was adjusted to give the maximum size to the residue outlet, with the result that a considerable quantity of juice and fine tissue was discarded with the seeds.

A suitable recipe was finally developed, and, calculating this on

100 lb. fruit used, the yield would be 36 gallons (or 440 lb.). The recipe on the same basis becomes :—

Pulp	..	..	..	9 gallons.
Sugar syrup	..	..	..	25 „
Citric acid	..	..	..	1 $\frac{1}{2}$ „
Potassium metabisulphite	..			140 grs. (5 ozs.)
Strawberry red	..	..		2 pints.

It should be emphasised that until the experiments have been transferred to the semi-commercial scale it is impossible to recommend definitely the above recipe for use on a commercial scale.

Strawberry, No. 2.

The fruit was pulped by the machine adjusted with a smaller outlet for residue. More pulp was obtained through the sieve, but even so it was necessary to rub the residue through a further sieve to obtain a reasonable yield.

A heavier sugar syrup was used in this case. (Specific gravity 1.29 corresponding to nearly 60% sugar). The materials and quantities added to the pulp and juice from 100 lb. of fruit are as follows :—

Pulp	..	..	..	9 gallons.
Syrup	..	..	..	9 „
Citric acid	..	..	..	1 gallon.
Potassium metabisulphite	..			63 grs. (2. ozs.)

The alteration in recipe resulted in a considerable reduction in the proportion of sugar syrup to be added. Whilst this caused the yield of squash from a given quantity of fruit to be reduced (100 lb. fruit would give 20 gallons of squash), the product itself contained more fruit pulp and would consequently be expected to be fuller in fruit flavour than that afforded by the former recipe. This was found to be the case. Although neither this product nor the preceding one possessed the delicate characteristic flavour of the 1934 squash, the diluted material was pleasant and refreshing.

Loganberry.

It was necessary to sieve the residue twice to obtain a reasonable yield of pulp and juice. The flavour was full and pleasant eight months after making.

Black Currant.

The fruits were milled complete with stalks. The pulp was extremely viscous, and the majority of the seeds were removed only by sieving the pulp after the syrup had been added.

The addition of water was tried in an attempt to obtain a less viscous product, but the result was not altogether satisfactory. It is probable that some fermentation treatment of the pulp may be more efficient in breaking down the jelly aggregates.

The appearance of the squash was not very attractive on account of its gelatinous nature, but on dilution with four parts of water to one of squash the tissues separated satisfactorily and the appearance was excellent. The flavour was very good. A full, clean aroma of black currants was associated with the characteristic flavour of the fresh fruit.

From the point of view of flavour, this squash was the most satisfactory of all the 1935 experimental products.

GENERAL DISCUSSION.

The object of the preliminary work indicated in this report was to determine whether products of the squash type could be made from English grown soft fruit, and whether the nature and character of the experimental products merited further detailed investigation. The results show that attractive beverages can be produced and it remains to examine some of the specific problems that have arisen in the course of the experiments of the last two seasons. The complete separation of seeds and skins without discarding too much of the finer tissues of the fruit probably calls for the use of finer sieves than that fitted to the pulping machine. 1'64in. sieves have been used on some squashes from the first season's stock, and have been capable of removing the whole of the seeds. The use of a larger sieve (1/16in.) is recommended to effect the first separation. The loss of appreciable quantities of juice and tissue in the residue is of economic importance in cases where no other products are being made, but otherwise, the residue can be added to any pulped fruit that is to be pressed to remove the juice for filtration and ultimate conversion into syrups or fruit juices.

The intensity of flavour is greatly influenced by the method of adding the sugar to the fruit pulp. The gravity of the thick material obtained through the sieve is quite low, and the least dilution of flavour would be attained by the incorporation of solid sugar in the pulp and juice. Although such a procedure has not actually been tried it is obvious that the resulting product will have the consistency of a thick purée and will not possess the familiar physical characters of citrus fruit squashes. But whilst the use of solid sugar does not appear to be advisable for squash production it is important to use a sugar syrup of such a strength that the gravity required for the squash is reached without the addition of an undue quantity of syrup. It is not desirable to lay down narrow limits

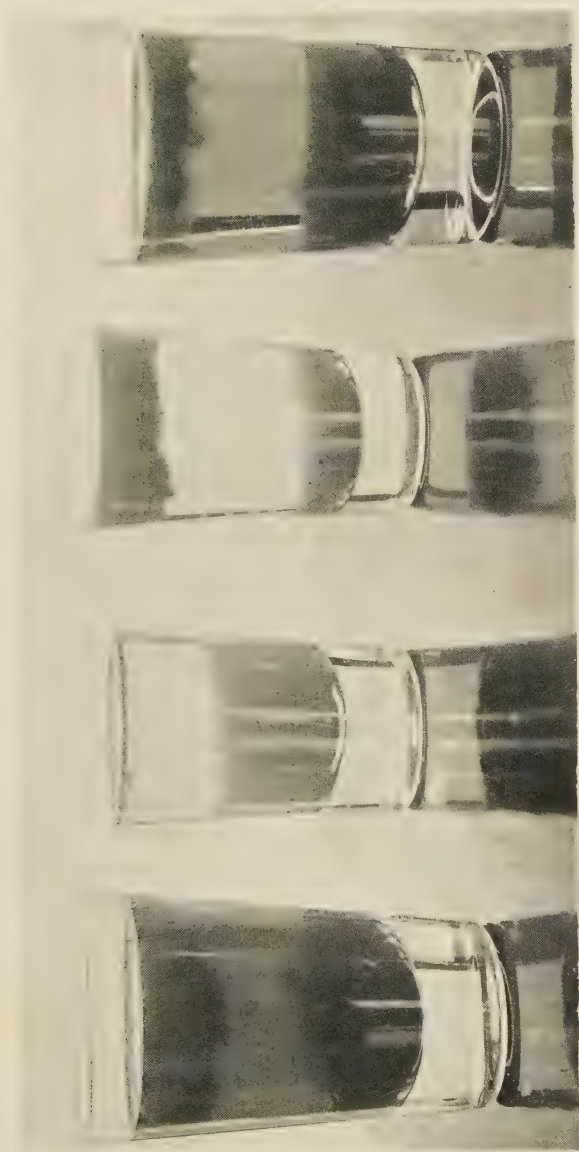


FIGURE 1.
DILUTED FRUIT SQUASHES.
Left to Right : Raspberry, Strawberry, Blackcurrant, Loganberry.

for the strength of the sugar syrup as the gravities of the juices will naturally vary from season to season, and the final gravity of the squash will depend on the degree of dilution which is recommended for any particular product. Satisfactory results may be expected if simple syrups (*i.e.* pure sugar solutions) with 50-60% sugar are used.

It has been found on several occasions that pasteurisation of the squash is not satisfactory. A definite taste of "cooked" fruit was noticed when temperatures of 165°F. were maintained for half an hour. The effect of the heat treatment was considerably greater than in the pasteurisation of syrups and this is possibly due to the combined action of the heat and acidity (which was about 2% as citric acid) on the solid portions of the tissues. The use of SO₂ is in accordance with the general commercial procedure in the squash industry, and provided that the statutory limits are not exceeded, the flavour of the product is not adversely affected. It is probable that 250 p.p.m. of SO₂ are sufficient to prevent fermentation and mould growth if cleanliness is observed in all the processing manipulations.

The SO₂ preservative, however, does introduce a complication by reason of its bleaching action on the squashes and the use of a certain amount of artificial colouring matter is essential. The Ministry of Health exerts a stringent control over the materials used for this purpose, but specific colouring agents which are suitable for all the berry squashes are available. Apart from the use of dyes as a remedy for the bleaching action of the SO₂, some degree of artificial colouring would be inevitable if a standard product was desired. The different varieties of any given class of fruit all vary in actual colour and in intensity of colour, and this is also true of fruit in bulk when considered from season to season. Standardisation of colour is most important, especially in products which rely to a certain extent on their attractive appearance. The materials that have been used in the experiments were water soluble powder colours, $\frac{1}{2}$ oz. of powder being dissolved in one pint of warm water.

Fig. 1 illustrates the appearance of four fruit squashes diluted ready for consumption.

SUMMARY.

1. Two series of experiments are described in which the possibility of producing fruit squashes from English fruits was investigated.

2. It is shown that attractive products can be made. The flavours of most of the squashes were very attractive, but the adjustment of the texture of the fruit tissues needs further investigation.

INVESTIGATIONS ON FRUIT PRODUCTS.

VIII.—PRODUCTION OF FRUIT WINES.

- A. THE EFFECTS OF (a) DILUTION OF THE JUICE AND (b) THE ADDITION OF PRESS CAKE.
- B. THE EFFECTS OF (a) TYPE OF SUGAR AND (b) TYPE OF YEAST USED FOR FERMENTATION.
- C. YEAST NUTRITION IN FRUIT WINES.

PROGRESS REPORT.

By VERNON L. S. CHARLEY.

The first report in this series (1) included a section dealing with the preliminary programme of experiments carried out on the production of wines from English soft fruits. No attempt was made at that stage to investigate particular problems; arbitrary recipes were used and the experimental data so obtained have been taken subsequently as starting points for a series of studies into exact conditions and recipes involved in fruit wine manufacture.

The present communication deals with four special features of the production of fruit wines, and these are discussed for convenience under the three headings shown in the title above.

A. EFFECT OF (a) THE DILUTION OF THE JUICE AND (b) THE ADDITION OF PRESS CAKE.

(a) Strawberry Wines.

Four wines were prepared as follows :—

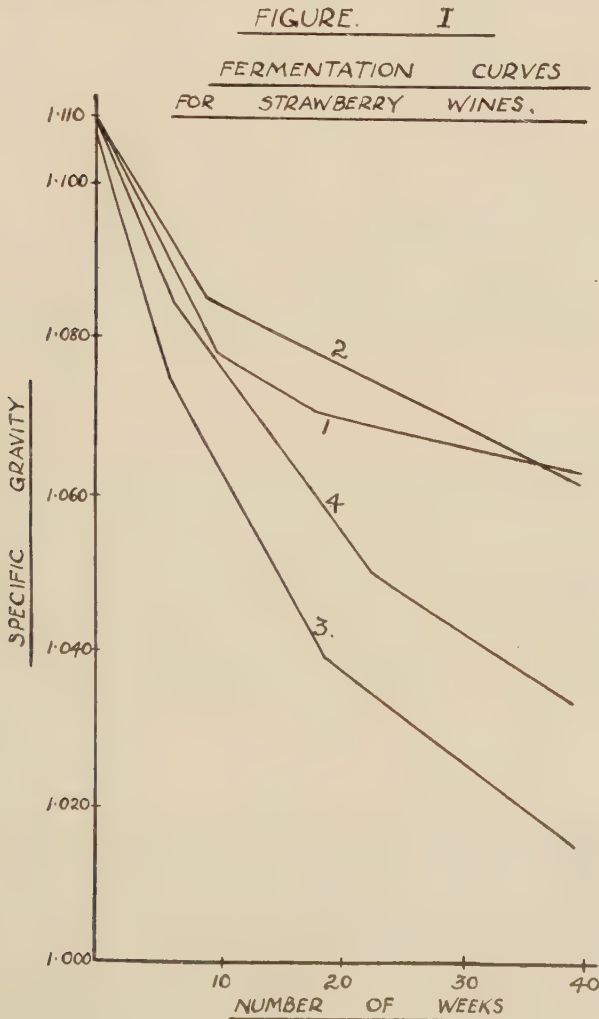
Three lots of fruit which had been discarded in the grading room on account of malformation, bird-pecking, or condition of fruit, were crushed in a cask on the following dates :—

21/6/34 (28 lb.) ; 23/6/34 (48 lb.) ; 27/6/34 (56 lb.). Considerable fermentation ensued and on 2/7/34 the juice was expressed, 10 gallons of juice with gravity 1.013 being obtained. This juice was

used as the basis of a dilution experiment according to the following scheme :—

DILUTION OF STRAWBERRY JUICE FOR WINES.		
Number of wine.	Gallons of juice.	Gallons of water
1.	$4\frac{1}{2}$	nil
2.	3	1
3.	2	2
4.	1	3

The sweetened juices (specific gravity 1.110) were fermented in $4\frac{1}{2}$ gallon casks, the progress of the various fermentations being shown in Figure I.



The analyses of the wines in May, 1935, are given in Table I.

TABLE I.
ANALYSES OF EXPERIMENTAL STRAWBERRY WINES.

Wine.	Specific Gravity.	Acidity per cent.	Tannin per cent.	Alcohol (by weight) per cent.
1.	1.064	0.78	0.08	9.42
2.	1.060	0.69	0.06	9.84
3.	1.014	0.58	0.05	14.07
4.	1.031	0.51	0.04	12.68

TABLE II.
FLAVOUR OF EXPERIMENTAL STRAWBERRY WINES.

WINE.	MAY, 1935.		FEBRUARY, 1936.	
	AROMA.	FLAVOUR.	AROMA.	FLAVOUR.
1.	Rather coarse and undeveloped.	Heavy pungent flavour. Distinct and rather coarse after-taste.	Well developed: not typical of fruit.	Still heavy, but decidedly smoother than in May. Flavour acquiring slight "sherry" character.
2.	Fragrant and clean.	Very soft and full-bodied. Smooth and mellow.	Slight aroma—"sherry" character pre dominant.	Full and rich. Very smooth and mature. "Sherry" character noticeable.
3.	Full and attractive.	Very full flavour with predominant alcoholic character. Fruity but rather rough.	Penetrating alcoholic aroma. Clean and definitely of the "sherry" type.	The alcoholic character was outstanding and probably contributed to the slightly rough flavour. 'Sherry' flavour quite distinct.
4.	Slight but delicate and characteristic of the fruit.	Clean, fullfruity flavour. Sufficient character, though not a real strawberry taste.	As for No. 2.	Very good. Mature and mellow. No fruit character present, but wine similar to many types of brown sherry.

It is difficult to explain the more complete fermentations which were associated with the more dilute juices. It is evident that the first two wines contained more nutrient material derived from the juice than Nos. 3 and 4, and yet their fermentations were protracted and only half completed. A possible explanation is the presence of a naturally occurring yeast inhibitor in the juice. The effect of this substance would be greater in the undiluted juices, but would only partly explain the observed results as the effect of dilution is reversed in Wine Nos. 3 and 4. This tentative suggestion implies that the retarding effect of the inhibiting substance is greater than the accelerating action of the nutrients in the juice.

The flavours of the wines were critically considered on several occasions but the data given in Table II include the more important observations.

The flavour tests indicate that some dilution of the juice is advisable to obtain a suitable intensity and character in the flavour of the wines. From a commercial point of view, the fourth wine presented the most satisfactory combination of characters, and had it been possible to store the products in wood instead of glass it is certain that even better wines would have been produced.

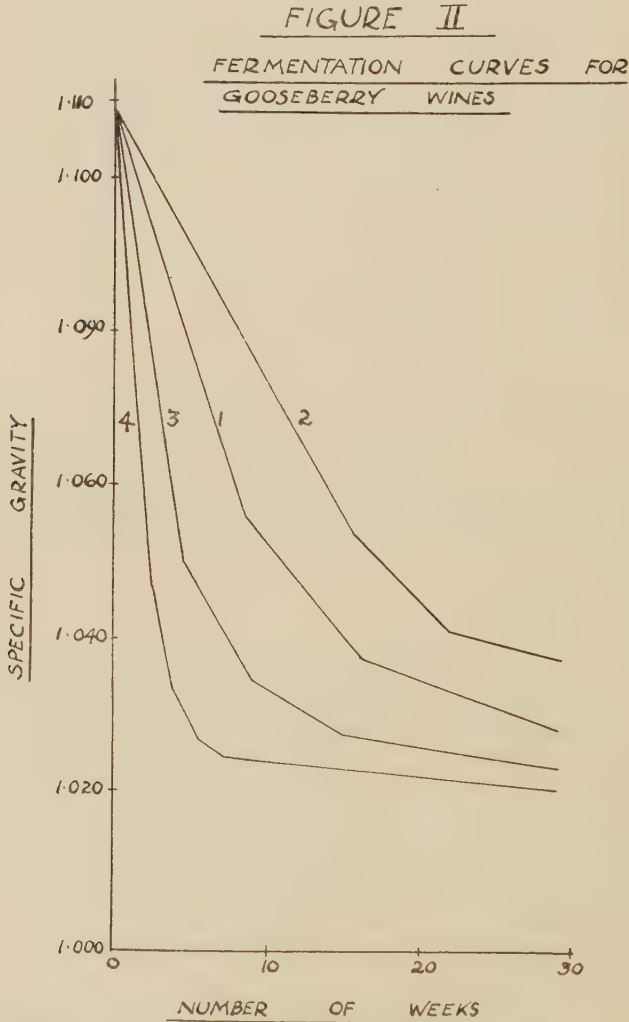
(b) **Gooseberry Wines.**

1 cwt. low grade red gooseberries were thoroughly crushed in a cask on 20, 7, 34 and 1 gallon of 45% sugar syrup and 2 gallons water added. Fermentation commenced immediately and after 4 days the juice was expressed. The 9 gallons of juice were divided into four lots, and portions of the pressed material remaining in the cloths were added to two lots of juice according to the under-mentioned scheme.

<i>Wine</i>	<i>Gallons of Juice.</i>	<i>Gallons of Water.</i>	<i>Pounds of Press Cake.</i>
1	2½	1	Nil
2	2½	1	2
3	1	2	Nil
4	1	2	0.5

The pomace was finely divided and was used in the correct proportion with reference to the volume of juice being used for each wine. The two casks to which the pomace was added were not quite filled, in order that the bulk of the solid material might not be forced through the bung hole but would remain in the fermenting medium throughout the fermentation.

The progress of the various fermentations is shown in Figure II. Small amounts of ammonium phosphate were added to each wine on 18/9/34.



The graphs indicate that the more dilute wines have fermented to a slightly greater degree, being similar in this respect to the strawberry wine series. The effect of the pomace, however, was not consistent, either in its effect on the rate of fermentation or on the ultimate flavours of the wines, as will be seen from Tables III and IV.

TABLE III.
ANALYSES OF EXPERIMENTAL GOOSEBERRY WINES.
(August, 1935).

Wine.	Specific Gravity.	Acidity per cent.	Tannin per cent.	Alcohol (by weight) per cent.
1.	1.023	1.02	0.046	11.68
2.	1.029	0.88	0.046	11.92
3.	1.020	0.99	0.040	9.68
4.	1.015	0.97	0.034	8.98

TABLE IV.
FLAVOURS OF EXPERIMENTAL GOOSEBERRY WINES.

WINE.	JULY, 1935.		FEBRUARY, 1936.	
	AROMA.	FLAVOUR.	AROMA.	FLAVOUR.
1.	Pungent, but quite unlike the fruit.	Rather rough. Very little mellowing. Too acid	Slight "sherry" aroma.	Distinct 'sherry' type of flavour, but very little mellowing.
2.	Pleasant and vinous.	Good delicate, flavour, clean and similar to to 'hock' type of wine. But too sweet.	Definite 'sherry' aroma.	Rather sweet, but soft and mellow. Definite grape wine character.
3.	Slight.	Very good flavour. Smooth and clean.	Slight.	Mellow and very fully flavoured. Maturing into a product similar to grape wines.
4.	Slight.	Thin flavour. Unattractive. Not so smooth or full as Nos. 2 or 3.	Slight.	Thin. Slightly acetic.

The gooseberry wines show interesting possibilities, and need further investigation to determine the best conditions for fermentation. Nos. 2 and 3 were most attractive, even though storage was in glass and not in wood. Once again the occurrence of a "sherry" type of flavour was noted in one wine and, as in the strawberry wines, the products had lost all trace of the characteristic flavour of the fruit. Maturing processes had effected noticeable changes during the last eight months.

(c) Loganberry Wines.

1 cwt. of very ripe berries from a commercial plantation in Worcestershire were crushed on 1/8/34 and 1 gallon 45% sugar syrup added. Fermentation occurred at once, and by the evening of 3/8/34 had developed to such an extent that the juice was expressed, and used for the following experiments :

<i>Wine.</i>	<i>Gallons Juice.</i>	<i>Gallons Water.</i>	<i>Pounds of Press Cake.</i>
L.A.	2½	1½	½
L.B.	1	2½	3½
L.C.	1	3	¾

The diluted juices were sweetened to a gravity of 1.100 with cane sugar, and fermentations proceeded without any addition of yeast. After completion of a quick fermentation, the wines were sweetened and filtered. The analyses of the wines in May, 1935, are given below :

TABLE V.
ANALYSES OF EXPERIMENTAL LOGANBERRY WINES.

Wine.	Specific Gravity.	Acidity per cent.	Tannin per cent.	Alcohol (by weight) per cent.
L.A.	1.037	1.12	0.09	11.50
L.B.	1.042	0.90	0.10	11.96
L.C.	1.037	0.74	0.06	11.80

The rate of fermentation of the wine was slightly retarded by the excess dilution of the loganberry juice, and so differs from the strawberry and gooseberry series ; but in all three cases fermentation was continued, although at slightly differing rates, until all the sugar had disappeared. This is in marked contrast to the other types of wine, where the fermentations ceased at gravities varying from 1.064 to 1.014.

It will be seen that despite the dilution used for Wine L.A. the acidity was 1.12%, which is too high for such a product.

The flavours of the wines are indicated in Table VI.

The loganberry wines, unlike the strawberry and raspberry, were remarkable for the prominence of the "fresh fruit" flavour. The alcohol content was similar in all cases, and provided a powerful basis for the wines, whilst the acidity of 0.90% (as malic acid) in the second wine was not so apparent to the taste as would be expected, this probably being due to the somewhat elevated gravity of the wine. The second wine in the series possessed the most delicate fruit flavour of any of the experimental wines. Its character was unique, and the most promising in the whole series.

TABLE VI.
FLAVOURS OF EXPERIMENTAL LOGANBERRY WINES.

WINE.	JULY, 1935.		FEBRUARY, 1936.	
	AROMA.	FLAVOUR.	AROMA.	FLAVOUR.
L.A.	Heavy, fruity and aromatic, similar to port, but characteristic of the loganberry.	Rather flat and lacking in character.	Less aroma than in July.	Character much improved since July, but still not as attractive as L.B. or L.C.
L.B.	Most attractive aroma. Full, clean and very characteristic of the fruit.	Best of the three wines. Very full and fruity, with delicate aromatic character. Soft and mellow, and developing very quickly.	Very clean and fruity. True to fruit character.	Still the best wine. Definitely more attractive than at previous tasting. The fruit character, whilst present in a more subtle form, was predominant.
L.C.	Slightly less powerful than L.B.	Lighter in intensity than L.B. but attractive and fruity.	Less than in L.B. but attractive.	Not quite so aromatic as L.B., but pleasant, and with a definite 'port' type of flavour.

(d) Raspberry Wines.

1 cwt. second grade raspberries were pressed out without maceration on 26.7/34. $8\frac{3}{4}$ gallons juice and 16 lb. press cake were obtained.

The juice and the pomace were treated as follows :

RASPBERRY WINES.

Wine.	Gallons of juice.	Gallons of water.	Pounds of pomace.
1.	2	2	nil
2.	2	2	4
3.	1	3	nil
4.	1	3	2
5.	$1\frac{1}{2}$	4	$3\frac{1}{2}$
6.	$1\frac{1}{2}$	4	7

The press cake was disintegrated and mixed into the diluted, sweetened juices and allowed to remain in contact with the fermenting liquors until the wines became dry. A further quantity of sugar was then added and, when fermentation finally ceased, the wines were immediately removed from the top and bottom deposits and filtered.

The first, third and fourth wines were exceptionally slow in fermenting and the specific gravities never fell low enough to warrant any further sweetening.

The dilutions employed in Wines 3-6 were substantially the same, but Nos. 3 and 4 were fermented in $4\frac{1}{2}$ gallon casks, whereas the other two were made up to a volume of 6 gallons and fermented in suitably sized casks. No significant effect of the addition of pomace in No. 4 was noticeable, but the large increase in pomace used in Nos. 5 and 6 was reflected in the considerably faster fermentations in these two cases. The amounts of pomace used in Nos. 2 and 4 were chosen to represent the weight of pomace associated with the actual amount of juice used in the given experiment.

The gravities of the various wines on 13/8/34, when wine No. 6 became dry, give an indication of the various rates of fermentation. No. 1, 1.007; No. 2, 1.012; No. 3, 1.035; No. 4, 1.034; No. 5, 1.017; No. 6, 1.000.

The analyses of the wines in May, 1935, are given in Table VII.

TABLE VII.
ANALYSES OF EXPERIMENTAL RASPBERRY WINES.

Wine.	Specific Gravity.	Acidity per cent.	Tannin per cent.	Alcohol (by weight) per cent.
1.	1.038	0.80	0.04	11.29
2.	1.031	0.81	0.10	13.66
3.	1.026	0.57	0.02	10.10
4.	1.033	0.61	0.04	11.56
5.	1.028	0.65	0.05	11.92
6.	1.016	0.43	0.03	13.00

The increased dilution in Wines Nos. 3 and 4 appreciably reduced the rate of fermentation but the addition of the larger quantity of pomace used for No. 6 increased the speed of fermentation to a considerable extent.

The colour, aroma and flavour of the wines are given in Table VIII.

The raspberry wines as a whole were disappointing. The reason is probably to be found in the rather excessive dilution used for Experiments Nos. 3-6. Two features are worthy of note. In the first place, the wines Nos. 1 and 6 developed the "sherry" type of flavour toward the end of the maturing period. Similar flavours have already been noticed in the Strawberry and Gooseberry series.

TABLE VIII.

FLAVOUR AND COLOUR OF EXPERIMENTAL RASPBERRY WINES.

Wine.	JULY, 1935.		FEBRUARY, 1936.	
	COLOUR.	FLAVOUR.	AROMA.	FLAVOUR.
1.	Pale red.	Peculiar "off" flavour. Fruity character quite disappeared.	"Sherry" aroma.	"Sherry" flavour first noticed in Dec., 1935. Now quite pronounced.
2.	Very deep red.	More fruit flavour. Rather acid.	True raspberry aroma.	Characteristic fruit flavour. Very alcoholic and slightly rough.
3.	Deep red.	Very thin and lacking in character.	Very slight.	Thin and unattractive.
4.	Lighter red.	Fuller in flavour than No. 3, but still unattractive	Very slight.	Thin and unattractive.
5.	Deep red.	Fair; fruity but lacking in real vinous character	Very slight.	Fuller than Nos. 3 and 4. Raspberry flavour but deficient in vinous character
6.	Off colour (brown).	Similar to No. 1.	"Sherry" aroma	Pronounced "Sherry" flavour.

The appearance of this type of flavour in the wines does not appear to be correlated with any definite treatment. In the strawberry series, the "sherry" character was present in all the different wines, but with a tendency to increase with increasing dilution. The gooseberry wine made from less diluted juice without the incorporation of any pomace also possessed this character, whilst the two raspberry wines which tasted of sherry were quite dissimilar in character. The first was a 2:2 dilution without the addition of pomace whilst the other was a 1:3 dilution with a heavy addition of press cake. It is obvious that some factor that has not yet been elucidated is concerned with this flavour phenomenon.

B. EFFECT OF TYPE OF SUGAR AND YEAST USED IN WINE-MAKING.

Raspberry Wine.

The use of sugars other than sucrose for fermentation processes had been considered in previous seasons but during the summer of 1934 a preliminary series of experiments with raspberry wine were carried out to determine whether various sugars had differing qualities from the point of view of alcohol production and flavour. The trials were extended to include experiments with a number of wine yeasts.

1 cwt. fair quality raspberries were crushed and allowed to macerate for 24 hours (17/5/34). 7 gallons of juice of gravity 1.040 were obtained, to which was added one gallon of water. The pomace from the press cloths was disintegrated and mixed with 7 gallons water and 3 quarts sugar syrup (specific gravity 1.20). The maceration was continued overnight, and the juice expressed and added to the initial bulk of juice. The total of 15 gallons was then divided into 3 equal portions which were each sweetened to a gravity of 1.110 by the addition of 15 lb. cane sugar, $1\frac{1}{8}$ gallons liquid glucose or $1\frac{1}{8}$ gallons of Brewer's invert sugar respectively to each separate portion of 5 gallons of juice. The sweetened juices were filled into glass gallons jars and pasteurised at 62°C. for $\frac{1}{2}$ hour. (A small quantity of fresh juice was not pasteurised, and was used as the inoculant in the natural yeast series).

The following pure yeast cultures were used :—

No. 32. from Steinberg Rhenish Wine.

No. 34 from Laureiro Portuguese Wine.

No. 37 from Reisling Rhenish Wine.

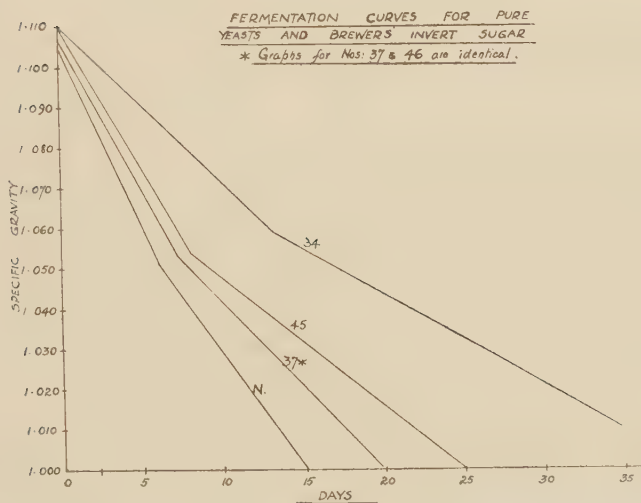
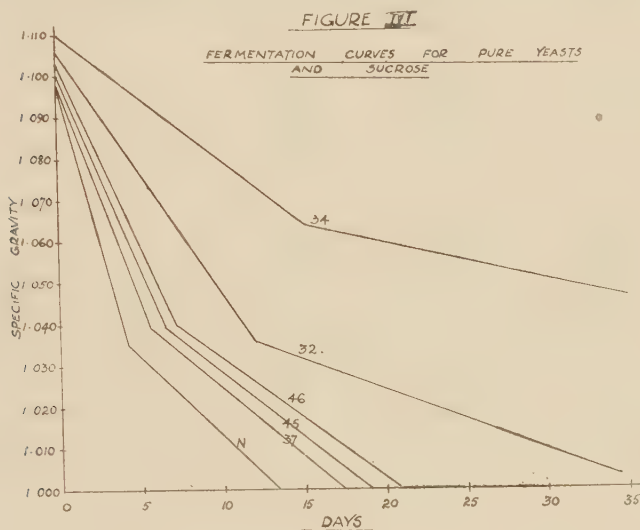
No. 45 from Champagne (No. 295 in A. Jorgensen's Laboratory Collection, Copenhagen).

No. 46 from grape wine (No. 305 in A. Jorgensen's Laboratory Collection, Copenhagen).

The yeasts were cultivated in dextrose yeast water media and 33 cc. were added to each gallon jar. A similar volume of fresh unpasteurised juice was added in the case of the Natural Yeast experiments.

As the wine in each treatment approached a gravity of 1.010—1.000 the appropriate sugar was added to raise the gravity by approximately 30 points.

The wines were eventually filtered through a pad of filter pulp in a large Buchner funnel and bottled. The nature of the initial fermentations in two series of wines before the second sweetening was effected is shown in the graphs in Figure III.



The following points of interest arise from a consideration of the graphs and from the observations and analyses made during the fermentation processes.

Rate of Fermentation by Individual Wine Yeasts.

If the yeasts are arranged in order of diminishing speed of fermentation it will be seen that some relationship exists in the three series.

Sucrose : Natural yeast, Nos. 45, 46, 37, 32, 34.

Glucose : No. 46, Natural yeast, Nos. 45, 37, 32, 34.

Brewer's Invert : Natural yeast, Nos. 46, 37, 45, 34.

In all three series the Natural Yeasts were amongst the most active. The significance of this observation may be lessened by the fact that it was not possible to determine the relative strength of the inoculating media, and it is probable that the numerical strength of yeast cells in the fresh juice added as inoculant greatly exceeded that of the pure cultures of yeasts added in the other cases. It is also possible that the Natural Yeasts were acclimatised to the fruit, whereas the wine yeasts suffered a disadvantage in this respect. The champagne and wine yeasts, Nos. 45 and 46 both afforded rapid fermentations but the slowest in each case were the Portuguese yeast Laureiro, and the Steinberg Rhenish wine yeast.

Relative Rates of Fermentation with Various Sugars.

The most noticeable feature of the fermentations when considered from the point of view of the different sugars was the incomplete fermentation in the glucose series. The sugar used was liquid glucose which has approximately the following formula : reducing sugars 48%, dextrins 33%, water 18%.

Thus the sugar product only contained half its weight of fermentable material and this is reflected in the incomplete fermentation and the low alcohol figures for the wines (See Table X).

No significant correlation was found between the rate of fermentation of the individual yeast cultures in the various types of sugar.

The wines were analysed in April, 1935, and the results are given in Table X.

The data in Table X need little comment. The tannin contents are not given, but they ranged between 0.03—0.06% for all the wines. It is interesting to observe that the alcohol percentages between 11—12% by weight are produced by the natural or pure yeast cultures without the addition of any yeast nutrient.

TABLE X.
ANALYSES OF RASPBERRY WINES.

Sugar.	Yeast.	Specific Gravity.	Acidity per cent. (malic acid)	Alcohol (by weight) per cent.
Sucrose	32	1.024	0.84	10.94
"	34	1.022	0.88	9.06
"	37	1.028	0.85	11.72
"	45	1.027	0.83	12.00
"	46	1.026	0.91	11.68
"	Natural	1.026	0.74	11.76
Glucose	32	1.039	0.80	5.19
"	34	1.047	0.81	4.60
"	37	1.044	0.77	4.94
"	45	1.044	0.85	4.94
"	46	1.037	0.84	5.54
"	Natural	1.047	0.77	5.25
Brewer's	34	1.027	0.88	11.00
Invert	37	1.028	0.88	10.48
"	45	1.029	0.79	10.78
"	46	1.026	0.76	10.48
"	Natural	1.027	0.84	10.40

Flavour Tests.

The wines were tasted by various panels of judges at different times but the data given in Table XI refer solely to tests carried out in July, 1935, and February, 1936. The observations relate only to the sucrose and Brewer's invert series, as the flavours of the glucose wines were very inferior and could not be compared with those in the other series.

Table XI does not refer to the glucose series or to the colour of the wines in the sucrose and Brewer's invert sugar experiments. The wines made from juices sweetened with glucose suffered from acetification, and an "off" flavour which is difficult to define. The low alcohol contents are responsible for the former condition, and whilst the nature of the constituents of the liquid glucose did not suggest that the extraneous flavour was due to their presence, the very syrupy consistency of the wine even after many months of storage, indicated that the dextrin material was still present.

The colours of the wines afforded the most marked difference between the two series. The sucrose wines possessed attractive deep red colours, those of Nos. 37 and 45 being most intense, and that of the naturally fermented wine being the least coloured. However, all the wines in the Brewer's invert sugar series were characterised by a definite brown tinge, similar to a light sherry, and the intensities of the colours were similar to those in the sucrose series.

TABLE XI.

FLAVOUR AND OTHER CHARACTERS IN RASPBERRY WINES.

SUGAR.	YEAST.	JULY, 1935.		FEBRUARY, 1936.	
		AROMA.	FLAVOUR.	AROMA.	FLAVOUR.
Sucrose.	32	Fair.	Delicate attractive flavour. Aromatic and smooth.	Slight.	Clean wine, without any outstanding character.
	34	Fair.	Lacking in character. Rather flat.	No aroma.	Quite deficient in character.
	37	Good.	Very full and characteristic flavour.	Good.	Smooth and fruity. Different character to any other in the series.
	45	Good.	Slightly softer than 37 but full and pleasant.	Good. Very fruity.	Full bodied and attractive. Distinct Raspberry character. Less vinous than No. 46. Smooth and pleasant after taste.
	46	Very good.	Vinous character predominating. Very attractive.	Very good. Slight fermentation.	Full bodied and characteristic of the fruit. Slightly rough after taste.
	Natural	Fair.	Clean full flavour, but slightly rough after-taste.	Slight.	Fruity flavour, but not intense. Quite clean.
Brewer's Invert.	34	Good.	Slight extraneous flavour present.	Off.	Poor flavour.
	37	Good.	Full and clean flavour, but slightly rough after taste.	Fair.	Fuller in flavour than the "Natural" wine.
	45	Very good.	Vinous flavour of fruity nature. Very mellow, and full.	Fuller.	Very good wine. Best of the whole series. Smooth and mellow, with full flavour, which, however, was not entirely characteristic of fruit.
	46	Good.	Similar to No. 45.	Less pronounced than No. 45.	Not quite so full and smooth as No. 45.
	Natural	Good.	Brisk flavour with raspberry character. Rather rough and undeveloped. Clean.	Pleasant but rather weak.	As before.

The chief feature of the results of the tasting of the wines is the fruity character of those in the sucrose series and the lack of this character in wines in the Brewer's invert experiments.

The champagne yeasts Nos. 45 and 46 appeared to give the best results.

C. YEAST NUTRITION IN FRUIT WINES.

The preliminary investigations carried out during the past four years into the production of wines from fruits in common cultivation in this country have been discussed in detail in the Annual Report of this Station for 1932 (p. 175). Both in that Report and the first section of this article, one of the most noticeable features is the incomplete fermentation of some of the wines. The 1932 results indicated that this was the case with strawberry, blackcurrant, and loganberry wines, and neither adding yeast cultures nor raising the temperature of the fermenting juice was successful in producing a completely fermented wine. More recent experiments have given similar results, and as many enquiries on this matter have been received from manufacturers carrying out preliminary experiments on production of fruit wines the problem appeared to be common and to occur in most seasons.

Many factors are known which will prevent the completion of fermentation by yeasts. The products of alcoholic fermentation, particularly ethyl alcohol, exert a retarding influence on the fermentative activity of the yeast cells. Many species of yeasts associated with berry and other fruits do not possess the capacity of producing alcohol greatly in excess of 10% by weight. Special pure cultures of yeasts, however, can ferment sugar until 12—16% alcohol has been produced. Again, the presence of chemical preservatives causes a more or less complete cessation of fermentation according to the amounts used. For example, the fermentation of sweetened juice obtained from fruits preserved in SO_2 is often impossible until the SO_2 has been removed by suitable treatment. Special strains of yeast, however, have been acclimatised to SO_2 and are available for fermentation under such conditions. Naturally occurring materials present in the juice may also act as inhibitors of fermentation. This is mentioned in the first section of this Report (page 195).

The dilution of fresh juices which is necessary to reduce their high acidity affects the natural nutriment which is available for the

development of the yeast cells and it is this particular aspect of the problem that is discussed in the experimental part of this report. Certain inorganic elements are necessary for the active development of yeast cells. These are nitrogen, phosphorus, calcium, magnesium, potassium and sulphur. By far the most important of these is nitrogen, for such small quantities of the other elements appear to be sufficient for normal yeast growth that it is only seldom that deficiencies of these occur. It has long been recognised that nitrogen deficiency in apples causes low nitrogen juices to ferment at very slow rates and in many cases to cease fermenting whilst the juice is still in a sweet condition. It has been usual to advise the addition of quantities not exceeding 2 ozs. of ammonium phosphate per 100 gallons to ciders that have prematurely ceased fermentation, but the writer is aware of many cases in which such treatment has not had the desired effect.

In view of the importance of determining the cause of restricted fermentation, it was decided to carry out a series of experiments on the fermentation of wine with various nutrient additions, including some of the more important mineral materials. The experimental details and the results are given in the next section.

Experimental.

1 cwt. of loganberries were thoroughly crushed and pressed in a hydraulic machine. The residue was disintegrated and macerated for 12 hours with 6 gallons of water and 1 quart of sugar syrup. The juice was pressed out and sweetened to 1.110. The second pressings only were utilised, in order to commence with a juice which would be extremely low in mineral constituents, and the first pressings were used for another line of work. Total nitrogen determinations were carried out on the sweetened juice, and the very low result of 0.0018% nitrogen was obtained.

The juice was measured in 750cc. lots into a series of 1,000cc. conical flasks and mineral additions made according to Table XII. The crystalline substances were weighed and dissolved in the sweetened juice.* The quantities of the various mineral and other nutrients have been calculated as ounces added per 100 gallons of sweetened juice.

* The quantities of materials used in Experiments 1-4 were based on the formula for Meyer's solution with the substitution of ammonium nitrate for ammonium tartrate. Experiment 5 involved the combined addition to one sample of all the salts used in Experiments 1-4.

TABLE XII.

RATE OF ADDITION OF YEAST NUTRIENTS.

(Amounts given as ounces per 100 gallons except where otherwise stated).

	SERIES A.	SERIES B.	SERIES C.	SERIES D.	SERIES E. Ammonium Phosphate only.
1. Potassium di-hydrogen phosphate (KH_2PO_4)	5	11	22	44	1. 11
2. Magnesium sulphate (MgSO_4)	5	11	22	44	2. 16
3. Calcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$)	0.5	1	2	4	3. 2
4. Ammonium nitrate (NH_4NO_3)	0.75	1.5	3	6	4. 1
5. Complete nutrient (1-4)	—	—	—	—	5. 0.5
6. Ammonium phosphate ($(\text{NH}_4)_3\text{PO}_4$)	0.75	1.5	3	6	
7. Liebig's extract of meat	2.5	5	10	20	
8. Yeast extract ..	2 galls.	4 galls.	8 galls.	16 galls.	

Three lots of sweetened juice were allowed to ferment without any additions and were used as controls. The flasks were closed with sterilised cotton wool plugs and gravities taken at 15.5°C . at regular intervals. None of the wines fermented to dryness, but when active fermentation had ceased the individual samples were filtered through paper pulp tightly packed in a Buchner filter and stored in miniature bottles for sampling purposes.

The rates of fermentation of series C. and E. are shown in Figures IV and V.

FIG. IV.

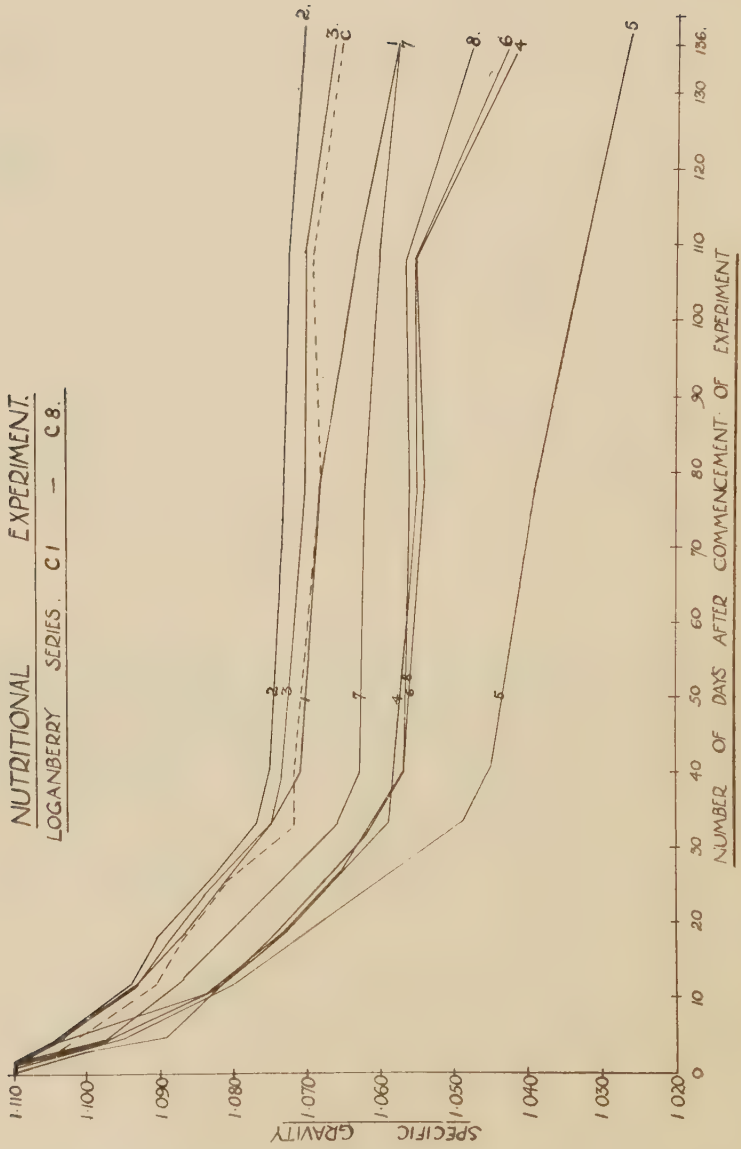
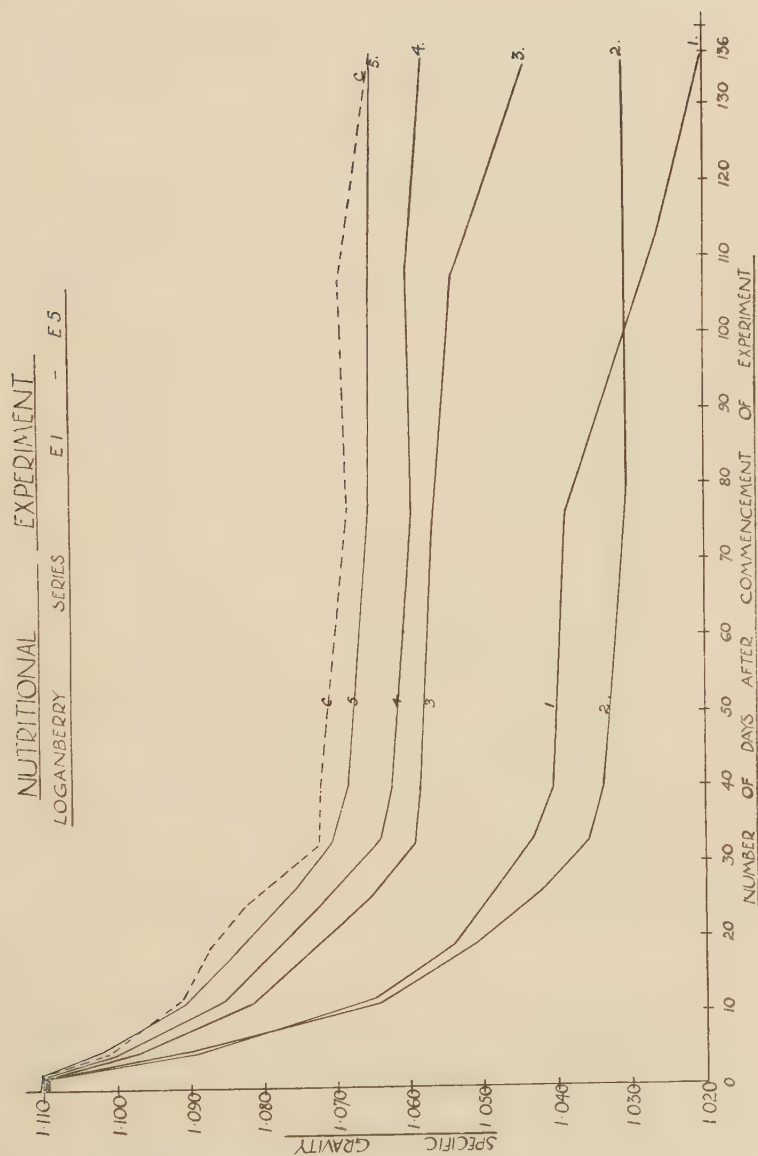


Fig. V.



The following are the chief points arising out of the fermentations :—

- (a) The extension or restriction of fermentation associated with the various nutrient additions is shown in the table below, where the numbers represent the difference in gravity between the various wines and the control series.

TABLE XIII.
EFFECT OF NUTRIENTS ON GRAVITIES.

NUTRIENT ADDED.		A.	B.	C.	D.	E. (Ammonium Phosphate only).
1.	Potassium di-hydrogen phosphate ..	3	4	8	10	1. 45
2.	Magnesium sulphate ..	-4	-5	-5	-9	2. 34
3.	Calcium phosphate ..	-5	-1	-1	-2	3. 21
4.	Ammonium nitrate ..	-1	15	24	27	4. 7
5.	Complete nutrient ..	11	36	39	39	5. 0
6.	Ammonium phosphate	6	18	23	24	
7.	Meat extract	6	12	8	13	
8.	Yeast extract ..	0	7	18	33	

With the exception of Nos. 7 and 8, the large quantities of materials used in Series D did not give results appreciably different from the C series where only half the quantities were used. Differences between the other series are more marked, the largest resulting from the addition of salts containing nitrogen.

- (b) Additions of the potassium salt were not effective in extending the fermentation to an extent that is significant for commercial procedure.
- (c) In every case magnesium sulphate (No. 2) and calcium phosphate (No. 3) retarded fermentation.
- (d) Ammonium nitrate and ammonium phosphate have extended the fermentation to the most considerable degree. This fact indicates that the predominant factor in the nutrition of the yeasts under the conditions of the experiments was nitrogen.
- (e) The actual amounts of nitrogen added in the form of ammonium salts are of considerable importance. Reference to the data for gravities lost during fermentation, tabulated under (a) above, shows that the separate addi-

tion of 3 ozs. per 100 gallons of ammonium nitrate (C.4.) and 2 ozs. per 100 gallons of ammonium phosphate (E.3.) have had practically similar effects. The ammonium nitrate addition contributed 0.007% nitrogen to the juice, whereas the ammonium phosphate yielded only 0.003% nitrogen. This discrepancy in the observed and calculated data suggests that the phosphate radical, in accordance with expectation, is exerting a definite stimulus on the yeasts. The same nitrogen figures, however, are capable of bearing a different interpretation. The total nitrogen in ammonium nitrate is partly in the ammoniacal form, and partly present as nitrate. The former type of nitrogen is assimilable by yeasts, whereas the latter is not directly available as a yeast nutrient. Consequently the figure of 0.007% for total nitrogen introduced into the wine base by means of ammonium nitrate may bear a purely fictitious relationship to the amount of assimilable nitrogen added in this way. It is known that chemical or biological conversion of nitrate into ammoniacal nitrogen does occur in soil and plant material, but the data obtained in the experiments do not give any information as to whether such changes occur in the type of material now under consideration.

- (f) The results obtained with Liebig's concentrated meat extract were inconsistent and small in magnitude.
- (g) The yeast extract used was in a dilute form and whilst the addition of 16 gallons per 100 gallons of juice caused a considerable increase in fermentation the quantity involved would be too great for commercial undertakings. Concentrated solutions would be expected to be more satisfactory, although it cannot be assumed that the nitrogen in the extract would be in a form suitable as a yeast nutrient merely because it has previously been assimilated by the yeasts.

Flavour Tests.

The wines were tested in February, 1936, when they had been in bottle for 14 months. Some difficulty was experienced in determining whether the differences in flavour in them were due to the presence of an extraneous flavour contributed by the added nutrient materials, or to the fact that those wines to which the nutrient had been added contained less sugar and approximated to dry wines. Owing to the inability to mature the various wines in

wood, insufficient blending and maturing had taken place. The more completely fermented wines were generally characterised by slightly rougher tastes than those which underwent less fermentation, but in these cases the flavours were affected merely by the absence of sugar and the presence of an increased quantity of alcohol.

The observations from the flavour tests are given in Table XIV.

TABLE XIV.

FLAVOUR AND OTHER CHARACTERS OF EXPERIMENTAL LOGANBERRY WINES.

No.	NUTRIENT ADDED.	SERIES A.	SERIES B.	SERIES C.	SERIES D.	SERIES E.*
1.	KH_2PO_4 ..	Slight "off" taste.	Fair. "Off" colour.	As for B.1.	Clean flavour Quite dis- tinct in colour.	Very strong alcoholic character. No unpleasant taste.
2.	MgSO_4 ..	Clean and pleasant.	Good, but sweet.	Trace of acetifica- tion.	Clean, but sweet.	Weaker than 1, but power- ful. Clean.
3.	$\text{Ca}_3(\text{PO}_4)_2$	Trace of acetifica- tion.	Good, but sweet.	Trace of acetifica- tion.	Clean, but sweet.	Very pleasant and smooth.
4.	NH_4NO_3 ..	Good.	Good. Smooth and mature.	Very good	Slight "off" flavour.	Very pleasant and smooth.
5.	Complete 1-4	Good.	Good.	Very good	Good.	Good, but sweet.
6.	$(\text{NH}_4)_3\text{PO}_4$	Good.	Good.	Clean.	Good.	—
7.	Liebig's meat extract ..	Suspicion of "off" taste.	Definite "off" taste.	As for B.7.	Definite malt type of flavour	— — —
8.	Yeast extract	Fair.	Acetic.	Clean and pleasant.	Weak in character.	— —

* Series E: Addition of Ammonium Phosphate only.

The data contained in Table XIV suggest the following conclusions:—

- i. Liebig's meat extract at all strengths imparted a definite taste to the wine.
- ii. The large quantities of mineral salts added in series C and D did not impart noticeable flavours to the wines, except in the case of D.4 (ammonium nitrate).

- iii. Wines receiving the complete nutrients (A.5, B.5, C.5, and D.5) were quite free from any suspicious taste.
- iv. 16 ozs. ammonium phosphate per 100 gallons of wine did not affect the flavour (E.2).
- v. Potassium di-hydrogen phosphate affected the colour to an appreciable degree. The bright deep red colour was changed to a definite brown, similar to sherry.

The wines were remarkable for the fullness of flavour, which was characteristic of the majority of the wines in the five series, when it is considered that second pressings of juice were used. The acetic tastes noticed in a few of the wines always occurred in those which had undergone only slight fermentation. In these cases, the alcohol content was not sufficiently high to suppress the acetic bacteria.

The actual alcoholic strengths of a few of the wines are as follows:—Control 6.68%, C.5. 11.6%, E.1. 12.3%.

It is possible that the alcohol content in E.1. prevented the fermentation proceeding to completion. This wine contained the largest percentage of alcohol of any of the wines, but loganberry wines made from the first pressings of juice have contained up to 14% of alcohol (by weight) without the addition of yeast or nutrients.

SUMMARY.

A. Four series of wines have been made from strawberries, gooseberries, loganberries, and raspberries. Attractive wines were made in each series, but results from the addition of press cake to the fermenting wine or of varying dilutions of the fresh juice with water or syrup were not sufficiently consistent to draw definite conclusions.

The strawberry wines remained in a sweet condition, and acquired a definite "sherry" type flavour. In the gooseberry series, the addition of pomace had marked effects, and two of the wines possessed flavours similar to those of hock.

The raspberry and loganberry wines retained their individuality throughout the maturing period of 18 months and the latter included wines of a most promising character.

B. Raspberry juice was sweetened with cane sugar, Brewer's invert sugar and liquid glucose, and the sweetened juices were pasteurised and fermented with natural yeasts and four types of pure wine yeasts. The glucose series remained very sweet and be-

came acetified. The sucrose and Brewer's invert wines were similar to each other in fermentation respects. The best yeasts were those isolated from champagne.

C. The sweetened second pressings from loganberries were allowed to ferment after the separate addition of a number of mineral and other nutrients. The control wines, to which no additions were made, ceased fermentation at a gravity of 1.060. The fermentations of the other wines were extended to varying degrees, a gravity of 1.015 resulting from the use of 11 ozs. ammonium phosphate per 100 gallons.

Nitrogenous nutrients extended fermentation to the greatest extent. Calcium and magnesium salts inhibited fermentation to a slight degree.

With the exception of meat extract, the added materials exerted very little detrimental effect on the flavour of the wines.

REFERENCE.

- (1) CHARLEY, V. L. S. *Ann. Rept. Agr. and Hort. Res. Sta., Long Ashton, Bristol*, p. 175, 1932.

THE CULTIVATION OF THE CRICKET BAT WILLOW—*Salix Caerulea*— ON SEWAGE FARMS.

By H. P. HUTCHINSON.

The evidence afforded by the results obtained from experiments on the manurial requirements of willows (1) suggested that the conditions existing on sewage areas should be favourable to the growing of Cricket Bat willows. The available data bearing on this point have been since collected and show this view to be supported by the following facts :—

- (1) Basket willow crops when grown on sewage soils produce the heaviest yields of rods.
- (2) Bat willow trees planted near manure beds make particularly rapid growth. An authentic case is known where a bat willow set, two inches in diameter, attained a girth measurement of 48 inches at the end of the ninth year from the date of planting.
- (3) In the winter of 1935-36, 119 bat willow trees grown on a sewage farm in the West of England were cut as mature trees. To the writer's knowledge they were planted in the spring of 1923, and at the time of felling had attained girths of from 46 to 50 inches.
- (4) The writer's notes on 50 bat willow trees grown on a sewage farm in the Thames Valley are as follows :—

DATE OF PLANTING—WINTER 1933-34.

	<i>Spring</i>	<i>February</i>	<i>July</i>
	1934.	1935.	1935.
Average Girths	4 inches.	7 inches.	10½ inches.

- (5) Sewage farm bat willows when properly managed are readily bought at good prices by willow merchants and bat makers, since they possess the quality of timber required, viz :—

- (a) A large amount of white (sap) wood relative to red (heart) wood.
- (b) Uniformity in quality of the wood as shown by the widths of the annual rings.

In planting bat willows on sewage farms care should be taken to plant well-grown sets of the variety, *Salix Caerulea*, and the following directions in management of the trees should be observed.

Directions for Culture on Sewage Farms.

- (1) To plant either rooted or unrooted sets at any time during the winter months.
- (2) To allow space intervals of 24 feet between neighbouring trees when planted in single line, increasing this distance up to 35 feet in cases where the rows are doubled.
- (3) To plant on the banks which are relatively dry sites bordering the settling pools and carrier drains.

A case exists where bat willows are making excellent growth growing on circular islands, 12—15 feet diameter, which have been made in rows in the settling pools.

Although the operations of planting are easy and very inexpensive, fencing, staking and other protection being unnecessary, neglect in the carrying out of certain essentials, although possibly without effect on the rates of growth of the trees, may result in the development of timber so defective as to be worthless.

The essential conditions to be observed are :—

I. To plant suitable material, which may be rooted trees or unrooted sets. In both cases the stems should be long enough to give a full 7 foot 6 inches length of clear bole between the ground level and the crotch of the tree. This length admits of 3 series of bats being cut out, allowing 2 feet 6 inches for each series. A fourth round would require the bole to be 10 feet long. This increase in length may ultimately enable more clefts to be cut from the tree, but the following objections may be reasonably urged against the practice :—

- (1) The risk of damage due to wind action increases with the height of the tree above ground level. Under sewage conditions the root of the tree is shallow on account of the water table frequently being near the surface. Hence anchorage may be insufficient in the cases of tall trees to withstand wind action and broken tops and uprooted trees may result before a felling size has been reached.

- (2) Shorter boled trees attain the required girths before longer boled trees.
- (3) The timber from short boled trees is of better quality than that from long boled trees.

The planting of rooted trees appears to be preferable to the planting of unrooted sets in that :—

- (a) Fewer deaths occur in the first season.
- (b) During the first year or two the rate of growth is greater.
- (c) They are more easy to plant firmly.

Whether rooted trees or unrooted sets are planted, in neither case should the diameter of the bole at ground level be greater than 2 inches, because, although the wood of the young tree never becomes part of the bat (being removed in the process of manufacture), defects in a thick set are liable to be more persistent in their effects on the wood than in the case of a set of small diameter.

The bark of the sets should be entire, which means that at no place on the bole should the underlying wood be exposed. Open scars, generally due to the removal of side branches, account for :—

- (1) The formation of trap bark which is due to the rate of ingrowth from the scar margins being exceeded by the radial growth of the stem.
- (2) The development of transverse bands of dark stained wood which are often the results of the presence of deep-seated dead snags.

II. To remove during the lifetime of the growing tree all shoot growths from the bole as soon as possible after they appear.

When observed as developing buds they may be rubbed off by hand ; if not observed until they have become shoots the latter should be cut off close to the bole. It is wrong practice to pull them off because the irregular scar which follows this practice is more difficult to heal, may become a centre of disease and later will produce a wavy grain mark in the timber.

III. To keep the sewage effluent from direct contact with the bark of the trees.

The raising of sets and young rooted trees for planting out purposes is a nurseryman's business : but, if the methods be learnt and carried out, many sewage areas have tracts of land which would be particularly suitable to this branch of bat willow culture.

REFERENCE.

- (1) HUTCHINSON, H. P. "Manorial Requirements of the Basket Willow." *Long Ashton Res. Stn. Ann. Rept.* 1924.

REPORT ON ADVISORY WORK, 1934-1935.

The number of enquiries received in the Department during the year again shows an increase over the previous period, comparison of the figures for the two years showing a nett gain of 1,732 in 1935.

It will be seen from the table of statistics which follows that a very large rise in the number of enquiries has occurred during the past six seasons, the increasing totals over the period reflecting the continuous expansion of the Advisory work of the Department.

The increase recorded during the past season is not the result of steady increases in all subjects but is due mainly to a new development in the work in Dairy Bacteriology resulting from the inauguration of the National Scheme of Accredited Milk Producers.

The statistics given in the table below refer to fourteen subjects and of these four are in connection with the work at the Berkeley Square Centre and ten relate to work at the Long Ashton Institute.

Increases are shown in all subjects of the Berkeley Square group, the total increase being 1,921, made up as follows :—Agriculture and Agricultural Chemistry (+ 109), Dairy Bacteriology (+ 1,753), Veterinary Science (+ 20), Poultry Pathology (+ 39). It should be noted that the enquiries recorded under Poultry Pathology refer only to Advisory work carried out by the Poultry Pathologist on behalf of the Veterinary Investigation Officer under a special working arrangement. The main work of the Poultry Pathologist, which is not concerned with ordinary advisory enquiries, is referred to in detail below.

The increases shown in the subjects above, other than Dairy Bacteriology, are regarded as normal developments of the subjects concerned. In particular, in Agriculture and Agricultural Chemistry, the increases appear to have resulted mainly from Broadcast Talks given by the officer responsible for the subjects, whilst in Veterinary Science and Poultry Pathology the increases have been made possible by the excellent relationships which have been established between the officers of those sections and the Veterinary Practitioners in the Province.

The Long Ashton subjects show a nett decrease of 331 enquiries, the figures for the various subjects being as follows :—Cider (+ 9),

Cider Instruction (+ 60), Pomology (— 195), Horticultural Chemistry (— 1), Economic Entomology (— 239), Economic Mycology (— 1), Insecticides and Fungicides (+ 42), Fruit Products (+ 22), Domestic Preservation (— 69), Willows (+ 41).

It will be seen that the decrease is accounted for by three subjects, Pomology, Economic Entomology and Domestic Preservation, other subjects showing negligible changes or definite increases.

The three substantial decreases are readily explained: in Pomology and Economic Entomology they are due to the sparsity of fruit crops in 1935, following the severe frost of May 17th, whilst in Domestic Preservation the decrease is the result of the measures taken by the Instructress to decrease the numbers of enquiries for the reasons given in the last report.

The subjects recording increases were not affected by the loss of the fruit crops and in connection with these increases the following points are of interest:—

In Cider Instruction the increase is mainly due to the re-entry of Dorset into the Scheme for Cider Instruction from May, 1935. In Insecticides and Fungicides, this was the first complete year since the appointment of the officer at present in charge of the subject: the increase here reflects steady progress, and it is especially interesting to find that the enquiries emanated mainly from commercial firms. In Fruit Products the rise in enquiries has been extremely rapid since the commencement of work in this subject in 1931 and advisory requests are still increasing. The rise in Willows is doubtless associated with the Officer's research work on cultural problems of cricket bat willows, since 166 of the total 275 enquiries related to this subject.

In the last report special mention was made of the success achieved in the Poultry Pathological section, established a year or two previous by the University on a self-supporting basis. It is gratifying to report that the work in this section has again shown a large increase during the year, as will be evident from the fact that during this period 90,484 blood tests and 934 post-mortems were carried out as against 73,751 blood tests and 653 post-mortems in the previous period. In addition to this vast amount of work, it has already been mentioned that the Poultry Pathological Officer has dealt with the advisory enquiries of the Veterinary Investigation Officer relating to poultry and has thus freed the latter for investigational work in other directions.

It must be emphasised that, in order to carry out the present volume of advisory work, the officers responsible for the various

sections of the work are working at very high pressure, and this is especially so in certain cases where the officers are also responsible for considerable programmes of research work. At Long Ashton the position has been especially acute in connection with the subjects of Cider and Fruit Products where one officer is wholly responsible for the latter subject and for a portion of the former. The position during the year was rendered more difficult owing to the fact that certain of the enquiries relating to Cider were unusually difficult, and called for extended investigations.

Advisory work is now classified under fifteen heads, viz.: Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Pomology, Horticultural Chemistry, Economic Mycology, Economic Entomology, Insecticides and Fungicides, Fruit Products, Domestic Preservation of Fruit and Vegetables and Willow Growing.

Statistics relating to enquiries are available for all subjects excepting Agricultural Economics, where the method of working does not lend itself to statistical tabulation of enquiries since the personnel of the Section concentrate on special problems of groups of farmers and economic surveys of farming methods and of special rural industries, and do not consider to any extent the special cases of individuals other than as they arise in group and survey studies.

Since the nature of the enquiries in Poultry Pathology differ in character from those in other subjects, involving mainly routine laboratory tests, and the numbers being very large, the work of this section is not included in the statistics, other than enquiries of a special order dealt with by the officer on behalf of the Veterinary Investigation Officer. This latter class of enquiry has increased greatly during the past two years, and the requests of this nature are included in the statistics for the first time on the present occasion.

The numbers of enquiries submitted to the Department during the past six seasons are summarised in the following table:—

	Year ending September 30th.					
	1930	1931	1932	1933	1934	1935
Gloucester (including Bristol) ..	365	414	871	849	945	1602
Hereford	137	159	169	310	337	360
Somerset	482	553	578	810	997	1119
Wiltshire	219	265	343	481	476	1365
Worcester	256	323	399	455	496	528
Other Areas	1025	919	960	1217	1562	1571
	2484	2633	3320	4122	4813	6545

The figures under "Other Areas" include enquiries from Devon and Monmouth, both of which contribute Annual Grants to the Long Ashton Institute. These counties do not rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Province for advisory purposes relating to Horticulture, whilst close touch is kept with the advisory personnel of both counties through the medium of the Horticultural Sub-Committee of the Provincial Advisory Conference.

The data do not include numerous enquiries dealt with in personal interviews, during survey work, local investigations, shows, etc.

The following features referred to in the sectional reports which follow call for special mention:—

Agriculture and Agricultural Chemistry.

Once again an increase in the number of requests for advice is recorded, which may be attributed, in part at any rate, to the influence of the fortnightly broadcast talks to farmers and the close contact which has now been established with the Gloucestershire and Somerset Branches of the National Farmers' Union.

A number of investigations have been in progress during the year. Mention may be made of an experiment designed to study the effect of fertilisers upon the nitrogen and mineral uptake in grass. The Department has also participated in field experiments designed to estimate the fertiliser value of Dried Poultry Manure, as well as continuing the study of the effect of poultry on the composition of grassland herbage.

Nutritional disorders in all classes of livestock claimed increasing attention, particularly in connection with the nutrition of poultry.

The Pig Husbandry Investigation, which is being conducted in conjunction with the Agricultural Organiser for Wiltshire, has recently been completed, and it is hoped that the findings of the investigators will be published early in 1936.

Dairy Bacteriology.

In this section the year has produced an enormous increase in the number of requests for advice over the large figures recorded in previous years. This increase was, in the main, due to the introduction of the Milk Board's National Accredited Scheme. With the commencement of this scheme the Provincial Laboratory undertook the examination of pre-licence and official post-licence milk samples

for the counties of Wiltshire, Gloucestershire and Herefordshire, and in order to cope with this extra work the University has provided a new laboratory, and also extra staff, which is under the direction of the Dairy Bacteriologist.

Apart from the usual volume of advisory work arising from problems relative to clean milk production, several local faults in milk and milk products, peculiar to the particular farm or dairy, have been investigated.

Examinations of Private, Trade and Local Health Authorities samples have also shown an increase, and the excellent co-operation between all parties, referred to in previous reports, continues to extend.

During the year, the Department has undertaken the testing of milk samples under the Ministry's Butter-Fat Scheme for the South Wilts Milk Recording Society.

Agricultural Economics.

Enterprise studies, financial accounts and special surveys are receiving much attention by the Agricultural Economist, who reports also an increase in the amount of advisory work arising from financial accounts. Probably the most interesting section of the Adviser's report is that dealing with the enquiry into management for milk production. This enquiry is being conducted at the request of the Milk Marketing Board, who, through the Ministry of Agriculture, are financing the work at this and other advisory centres. The grant-aiding of special investigations at Provincial Centres by Marketing Boards would appear to be the most satisfactory method whereby the various Boards could obtain authentic information on the many problems with which they are confronted.

Veterinary Science.

The efficient working of the Advisory Scheme in Veterinary Science is largely dependent upon the whole-hearted co-operation of the veterinary practitioners in the Province, and it is gratifying to note that this co-operation is now firmly established and that practitioners are receiving advice from the Veterinary Investigation Officer (the new official title for the Veterinary Adviser) on many problems concerning the diseases of sheep, pigs and poultry.

It is of interest to note that parasitic gastritis and enteritis of sheep, which was very prevalent last year, appears to have completely died out. Contagious Abortion and the sequelae continue to be a serious problem to the dairy farmer.

Poultry Pathology.

Whilst the Poultry Pathologist is not officially recognised as an Advisory Officer, his presence in the Province would appear to be more than justified in that during the year under review he examined over 90,000 blood samples and over 900 pathological specimens. In addition, he received 149 other requests for advice and in the assistance of the Veterinary Investigation Officer he visited 86 farms in the Province. It is important to note that as the Poultry Pathologist undertakes most of the advisory work in connection with the diseases of poultry, the Veterinary Investigation Officer is relieved of this work and therefore able to devote more time to the other branches of livestock.

It may not be out of place to mention that the Poultry Pathological section was established at the request of the counties of the Province on a self-supporting basis, and it is largely as a result of the co-operation of the County Staffs and the poultry farmers in the Province that it has made such excellent progress.

Economic Entomology.

For the first time in many years there was a considerable decrease in enquiries regarding fruit pests, undoubtedly reflecting the general loss of crop following the disastrous frosts of May, 1935. In all other branches the demand was maintained, with an increase in those concerning farm crops.

Codlin Moth and Plum Sawfly have become widespread and the severity of the attacks will necessitate the adoption of control measures in many plantations. Experimental work is in progress on both of these pests. The investigation on the Fruit Tree Red Spider has been completed and information is available on the value of dormant and summer washes. It is evident that a red spider wash must be included in the programme of treatment of winter-washed cider orchards.

Aphid attacks on plums that had been winter-washed were widespread and severe. Many attacks would have been prevented by using winter washes containing the correct amount of ovicidal tar oils.

Special lines of work included a survey of the pests of sugar beet; further progress in the study of the bionomics of the pea strain of the eelworm *Heterodera schachtii* and some further important results in the control of Flea Beetles in agricultural crops by means of a seed dressing. Several fresh lines of work were

commenced, including investigations on the Oat Eelworm, *Anguil-lulina dipsaci*, the possibilities of calcium cyanamide as a control for Wireworm, and the incidence and control of Lettuce Aphids.

Economic Mycology.

In Economic Mycology the total number of enquiries was practically identical to that of the previous year, although enquiries relating to fruit were somewhat fewer owing to the effects of frost.

Mr. P. W. Brian continued to assist in the investigation of vegetable diseases, and Mr. D. L. G. Davies, a post-graduate student, commenced work on *Fusarium* diseases.

The investigations carried out during the year covered a wide range of subjects and included under the heading of fruit diseases *Diaporthe perniciosa* in relation to dieback, leaf spotting and fruit rotting of apples, and the etiology of "crimp" and "red plant" of strawberries.

In the vegetable disease work, attention was concentrated on diseases of lettuces, and it was shown that certain varietal groups of lettuces exhibited much less severe symptoms of mosaic disease than others.

A complete control of the oecidial stage of mint rust in green-houses was achieved by hot water treatment of runners prior to planting.

The adviser drew the attention of Dr. K. M. Smith to two new virus diseases of tomatoes.

Sclerotinia Sclerotiorum and *Armillaria mellea* were recorded for the first time on hops. Attack by the former was associated with injury to the bines by late frost and with marked infection of many kinds of weeds in the hedgerows.

Willow Growing.

The year has been notable for two features :—

- (1) An increased demand for basket willows in conjunction with improved prices for these.
- (2) The continued extensive planting of the Cricket Bat Willow.

In connection with the former, the co-operative buying of willow rods by the Association of Workshops for the Blind, which require annually (according to figures supplied by the Secretary of the Association) about 700 tons, has stimulated production. As the

Association comprises only about one-half of the total number of Blind Institutions in the country the quantity of willow rods used by the Blind Workers would appear much larger than previously computed.

A new grower in Norfolk has planted new beds with varieties specially suited to the needs of the Blind Workers.

It should also be noted that the Competitive Classes for Willow Rods at the Bath and West Show at Taunton, initiated and organised by the Willow Officer as a new Show feature, showed clearly the excellent quality of English-grown willows.

The planting of Cricket Bat Willows in the West of England has been particularly marked; 4,700 Bat Willow trees have been planted on one estate near Minehead since 1933. Large quantities of bat timber have been exported and exports to Australia appear to be increasing.

The salient features of the work of each section during the year are summarised below :—

AGRICULTURE AND AGRICULTURAL CHEMISTRY.

A further increase in the number of requests for advice received, samples examined and visits to farmers and others has to be reported. It is a continued pleasure to place on record appreciation of the whole-hearted and valued co-operation and support of the County Agricultural Organisers in the Province and the members of the Assistant Staff in the Agricultural Chemistry Section of the Department, to whom credit is largely due for the efficient way in which the Advisory Scheme, so far as it concerns Agricultural Chemistry, has operated.

As in former years, specimens of weeds, herbage plants and rocks have been received for the purpose of identification and report as to commercial value, poisonous properties, etc., and the co-operation of the Departments of Botany and Geology in the University in connection with this work is readily acknowledged.

During the year ended September 30th, 1935, 704 requests for advice were received, which is an increase of 109 over the previous year. The number of samples examined in the laboratory totalled 1,001, of which 397 were advisory and 604 investigational.

A few notes on some of the samples are appended.

Soils.

The majority of the soils submitted were related to the problem of manurial requirements for, or failures occurring in plant growth. Some of the soils were from the "Minder" lead poisoning district of the Mendips.

Fertilisers.

The few fertilisers examined consisted of various by-products, such as carpet factory waste, and they were sent in for opinion as to their possible manurial value.

Limes and Limestones.

Most of the limes and limestones were received from farmers who were desirous of knowing the value of local and apparently cheaper forms of these materials.

Feeding Stuffs.

The large increase in the number of feeding stuff samples can be attributed partly to the apparent increase in digestive trouble occurring in all classes of stock. Examination revealed that, in the majority of cases, the foodstuff was not the prime cause of the trouble. In addition, there was a greater number of samples submitted by local firms who wish to keep a check on the correct "balancing" of compound rations sold to farmers.

Roots.

A considerable number of root samples were received from the County Experimental Centres.

Viscera.

The viscera examined were from animals suspected of either metallic or alkaloidal poisoning.

Investigational.

(a) Grassland.

(1) Nitrogen and mineral uptake.

A series of experiments were commenced in October, 1934, with the purpose of investigating the effect of various fertilisers, both singly and in combinations, upon the uptake of nitrogen and mineral constituents by grasses and clover.

Replicated plots have been marked out on a farm at Stoke

Gifford, manures applied and samples collected at fortnightly and monthly intervals. The herbage has been separated into its several species, and the grasses again divided into leaf and stem. Analyses are being carried out on each of these separations.

It is hoped to continue this experiment during the next season.

(2) *Teart Pastures of Somerset.*

During the past season very little progress towards a solution of the teart problem has been made. No complaints have been received from farmers and therefore systematic field investigations could not be undertaken. Laboratory investigations, however, were continued, and, at present, samples of soil, herbage and water are being examined.

(3) *Poultry Grassland.*

The study of the effect of poultry on the composition of grassland herbage has been continued, and 28 samples of herbage have been collected from seven different centres where County Egg Laying Trials were in progress. These samples are being analysed as time permits.

(4) *Sampling of Meadow and Pasture Herbage.*

In connection with the work of the Analysis of Fodders Subcommittee of the Agricultural Education Association, a meadow was systematically sampled immediately before mowing; 48 weighings were recorded and 24 samples taken to the laboratory for dry matter and nitrogen determinations. The results are to be submitted to statistical analysis and will provide much-needed information on errors involved in sampling the herbage of meadows and pastures.

(b) **Arable Land.**

(1) *Swede Varieties.*

Varieties of swedes grown on different types of soil in Somerset were analysed for dry matter content, and such data on the composition of home-grown foods have enabled the Adviser in Agricultural Economics to compare the value of feeding stuffs grown within the Province with the value of feeding stuffs grown in other parts of the country.

(2) *Sprouted Maize and Barley.*

Samples of sprouted maize and barley were analysed for farmers interested in this method of obtaining succulent fodder for live-

stock. As a result of the process of sprouting grain there was a loss of digestible carbohydrate and an increase in fibre content. Thus there would appear to be disadvantages rather than advantages in preparing such fodder for pigs and poultry.

(3) *Fertiliser Value of Dried Poultry Manure.*

At the request of the Ministry, the Department participated in the scheme of field experiments designed to provide an estimate of the fertiliser value of dried poultry manure. Experiments were conducted at five centres in the Province—at three centres on potatoes, and on sugar beet at the two remaining centres. The results of these experiments have been included in the last Annual Report of the Rothamsted Experimental Station.

(4) *Fertiliser Value of Chilean Nitrate of Potash.*

In continuation of problems concerning the manuring of sugar beet, experiments have been conducted at five centres with the object of estimating the value of Chilean nitrate of potash as a fertiliser for sugar beet. The results showed that this fertiliser could replace satisfactorily an equivalent mixture of sulphate of ammonia and potash salts.

(5) *Sugar Beet Factory Waste Lime Experiments.*

Experiments with this material, which are being carried out jointly by the Harper Adams and Bristol Provinces, are being continued, and in addition to the original experiments on the sugar beet crop, it is hoped to test the value of this material on acid grass and hay land, where it is frequently used, particularly in the near vicinity of the sugar beet factories.

(c) Livestock.

(1) *Poisoning of Poultry.*

In collaboration with the Poultry Pathologist, samples of poultry viscera were examined for poisons. These samples were obtained from chickens, ducks and geese kept on farms in the Mendip Lead Mine Districts of Somerset. Toxic amounts of lead were found in all samples and lead was also found in the soils over which the birds had been allowed to range. Chronic lead poisoning prevailed among the flocks on the farms where the investigations were carried out.

(2) *Poultry Nutrition.*

Since 1932, the Department has been in close touch with the poultry industry through the Poultry Pathologist and the Adviser

in Agricultural Economics. In consequence, the subject of poultry nutrition is becoming prominent amongst the activities of the Department.

Of necessity, however, attention has been limited as far as possible to those cases where malnutrition appeared to be the underlying cause of high mortality or poor production.

Among the various feeding troubles encountered, cases of Vitamin A deficiency have frequently occurred, while two cases of Vitamin B₂ deficiency have been recorded. Reports have been made on the mineral composition of many samples of poultry mash and on the feeding value of other samples. Where necessary, revised rations have been recommended.

(3) The Bath and West Society's Pig Investigation.

The field work in connection with this investigation, which is being conducted jointly by the Agricultural Organiser for Wiltshire and the Adviser, has been completed, and a full Report will be published in the Journal of the Bath and West Society early in 1936.

Other investigations, which were outlined in the previous report, have been continued.

DAIRY BACTERIOLOGY.

The requests for advice and the number of samples examined from both the productive and distributive trades have shown a large increase over the preceding year. In all, 2,178 requests for advice have been received compared with 425 for the last period, and 13,551 samples of milk and milk products have been examined. In addition 38 advisory farm visits were made.

Competitions.

Clean milk competitions have been successfully conducted in collaboration with the County Agricultural Organisers in Somerset and Worcestershire, and a very satisfactory competition arranged by the Gloucestershire Milk Recording Society has been completed. These competitions attracted 112 entrants, of which number 87 obtained results entitling them to Certificates of Merit.

County Registers of Accredited Producers.

With the advent of the National Accredited Milk Scheme the County Rolls in Somerset and Worcester were abandoned, but several members continue to submit periodical samples for their own information.

The Wiltshire Roll, however, has been continued with 150 members as compared with 74 for the preceding period.

From an educational aspect the value of County Accredited Rolls and the examination of periodical samples cannot be over-estimated. Any serious fault in the methods of production on the farm is immediately exposed by poor bacteriological results, and advice is sought at once as to ways and means of overcoming the trouble before it has become firmly established. The detection of sudden mastitis infection is one example of the valuable nature of this work.

Grade "A" Milk Samples.

The Provincial Laboratory has undertaken the examination of pre-licence and post-licence samples for three counties, namely, Wiltshire, Gloucestershire and Herefordshire. For this purpose the Ministry of Health technique is employed, but as the results are also utilised in an advisory capacity in the two first-named counties the coliform organisms content is determined in all dilutions and the keeping quality estimated for all pre-licence samples.

In Gloucestershire, a probation scheme has been put into operation by the County Agricultural Organiser to assist applicants for Grade "A" licence to attain the required standard of efficiency. Under this scheme each applicant submits three or more samples, at least one of which is of a surprise nature, until such time as Grade "A" bacteriological standard is well maintained.

A less extensive scheme similar in principle is in operation in Worcestershire.

Local Health Samples.

The number of samples examined under this heading shows a large increase over the figure for the previous period, chiefly due to the growing interest on the part of sanitary inspectors, and to the school milk scheme.

Special Advisory Work and Investigation.

Mastitis.

Special interest has again been taken in detecting the presence of mastitis infection in dairy herds by the examination of milk samples. The incidence of this disease has proved a serious stumbling block in the production of milk of Grade "A" standard and, from experience, it is evident that clinical examination is useless in detecting cows with chronic infections. In several cases individual cow samples of the complete herd have been examined, and

removal of affected animals from the herd has allowed the producer to obtain bacteriological counts of Grade "A" standard. Treatment of affected cows by the use of udder injections has been tried but with only very little success.

Efficiency of Low Pressure Steam Sterilisers.

The Dairy Bacteriologist has collaborated with the Wiltshire County Organiser in an investigation of the efficiency of low pressure steam sterilisers under farm conditions. The chief reason of the investigation was that, on account of their attractive initial cost, many low pressure sterilising outfits were being installed on farms under conditions which did not appear to make for efficient and economical operation, and it was felt that some information on these points was required. Over twenty sterilising outfits have been tested and a full report of the results will be issued in due course.

Methylene Blue Reductase Test.

Interest in this test in a modified form has been continued in collaboration with other Advisory Centres, but the serious limitations of the technique have not yet been completely overcome.

AGRICULTURAL ECONOMICS.

(1) Inquiries and Advisory Work.

During the year under review 557 farm visits were made in connection with financial accounts and enterprise studies. These were undertaken partly in order to discuss points of detail which could not be satisfactorily dealt with by postal methods, and partly to keep in touch with the systems of management operating in different parts of the Province. The number of letters to farmers in connection with these various types of records amounted to 2,192.

Milk production and problems connected therewith naturally predominate in this Province. Farmhouse cheese production has now returned to normal as a result of the improved terms made by and through the Milk Marketing Board. Milk producers generally are becoming keen to ascertain the effects of high or low yield upon costs, the financial advantages likely to accrue from the installation of milking machines and other related problems. Such suggestions are not new, but there is strong evidence that they are now receiving much more serious consideration.

In Worcestershire, the horticultural industry was seriously

affected by the frost which occurred in May, 1935. It had the effect of severely curtailing the apple and plum crops and of destroying the first picking of Brussels sprouts, besides retarding the season for other crops, so that the advantage which this area usually obtains from being able to market early in the season was lost. The position of small growers was particularly difficult since this had been the third successive bad season.

(2) Investigational Work.

The following summary is given :—

(a) Financial Accounts.

There are now 146 farms from which financial accounts are received. This is an increase of 11 on the previous year. The usual classification is given below :—

<i>Proportion of Permanent Grass.</i>	<i>No. of Farms.</i>	<i>Type of Farm.</i>	<i>No.</i>
0 — 30%	4	Fruit and Market Gardening	3
		Milk	1
31 — 70%	63	Fruit and Market Gardening	4
		Milk	21
		Cattle and Crops	7
		Mixed	31
71 — 100%	79	Milk	34
		Cattle and Crops	7
		Mixed	38
	146		146

Total Acreage, 64,226.

(b) Surveys.

In August, 1935, there was undertaken, at the request of the Lord Astor Group, a survey of the social and economic condition of the small market gardeners in the Evesham-Pershore area of Worcestershire. A special grant was received from the Group for this purpose and a report has been forwarded. The inquiry was confined mostly to growers of less than ten acres and altogether 71 records were obtained.

(c) Enterprise Studies.

(i) *Inquiry into Management for Milk Production.* This investigation, which was referred to in the previous report, now forms part of a much larger inquiry into the cost of production of milk. This inquiry was commenced at the request of the Milk Marketing Board, and is being carried out in co-operation with the other

advisory and research centres. Of the 152 producers who kept records for the winter period, 132 continued for the summer six months. In accordance with arrangements made between the Milk Marketing Board, the Ministry of Agriculture, and the Advisory Economists, the 68 farm records, for which a special grant has been received from the Milk Marketing Board, have been sent to the Board. This grant has been renewed so that the Board may receive a similar number of records for the second year.

(ii) *The Study of the Economics of Poultry Farming.* This has now been completed for the second year and a second report has been issued. The inquiry is being continued for the third year. Twenty-three specialised poultry farms of varying sizes and types are co-operating.

(3) General.

Meetings.

The customary meetings with groups of farmers in order to examine and discuss the results of farm management investigational work were held at various centres in the Province.

VETERINARY SCIENCE.

(1) Enquiries and Advisory Work.

Problems concerning cattle and pigs have occupied a greater portion of the advisory activities than in previous years with an increase in specimens submitted. 412 requests for advice were received, 476 pathological specimens were examined and 129 advisory visits were paid during the year.

The more common diseases of animals encountered in the Province are appended :—

Sheep.

Enterotoxaemia or “sudden death” among ewes and lambs was encountered in several flocks during the spring, but in no outbreak were the losses very severe.

Abortion among ewes as a result of *B. paratyphosus* *B.* infection appears to be on the increase.

Infectious conjunctivitis which causes temporary blindness has been a subject for considerable correspondence, silver iodide solution being the most successful treatment found.

Lamb Dysentery and Navel-ill continue to cause losses, but most farmers are fully aware of the measures necessary for control and losses are being much reduced.

Cattle.

Requests for advice concerning Mastitis have increased considerably, both practitioners and farmers forwarding samples of milk from suspected cows for bacteriological examination.

Contagious Abortion and the sequelae continue to be a serious problem to the dairy farmer. Blood testing of animals in infected herds has been carried out in an effort to devise a means of control.

Two outbreaks of Haemorrhagic Septicaemia were reported by a practitioner, serum proving efficient in controlling losses.

Pigs.

Swine Erysipelas, *B. Swipestifer* and *B. Swisepticus* infections have all been encountered during the year.

Some very severe outbreaks of mange have been diagnosed, treatment of individual cases being difficult and the cure protracted or unsuccessful.

Precautions against anaemia and parasites have become routine measures on many farms and losses from these causes become progressively less.

Poultry.

The Poultry Pathologist has continued to undertake most of the work in connection with poultry problems. All the more common diseases have been encountered. One outbreak of Infectious Laryngo-tracheitis and several outbreaks of Fowl Typhoid have occurred in the Province.

(2) Investigational.

The continued drought of the past summer has made any further investigations into the "teart" problem very difficult and no cases of the condition have been encountered.

In collaboration with local practitioners, the protection given by inoculation of serum into animals in flocks where losses from Enterotoxaemia had occurred was studied during the spring.

POULTRY PATHOLOGY.

Considerable further increase in the number of blood tests and post-mortem examinations has occurred and requests for advice have been more numerous.

The number of blood samples submitted and tested for Pullorum disease totalled 90,484* and, with few exceptions, were contributed by farmers in the Bristol Province.

934 pathological specimens were received for examination and the requests for advice advanced to 149.

In the assistance of the Veterinary Investigation Officer 86 visits were made to farms in the Province.

Paralytic conditions and so-called Fowl Paralysis have been the subject of most of the investigational work.

Parasitic diseases, especially Coccidiosis, and to a lesser extent tape worm infestations with the microscopical worm *Davainia Proglottina* have been responsible for the bulk of disease losses. A severe outbreak of Gizzard Worm (*Amidostomum nodulosum*) was encountered amongst geese, and successfully dealt with by the administration of carbon tetrachloride.

Fowl Typhoid has been met with frequently in the north of the Province and two outbreaks of Salmonellosis amongst chicks were diagnosed. In the latter conditions the symptoms simulated Pullorum disease.

A virulent Fowl Cholera and Infectious Laryngo-tracheitis were encountered each on one occasion.

Cases of poisoning by arsenic and salt continue to occur, the former from the use of rat poisons and the latter due to the use of salted scraps of household refuse. In one case of interest the birds ranged over a field which had been sprayed with salt to encourage the growth of mushrooms.

Toxic amounts of lead have been found several times in the viscera of unthrifty birds from the lead areas of Somerset.

Nutritional problems, especially of chicks, have been more numerous, especially on intensive plants. Rickets has been common and several instances of Avitaminosis A and two cases of Avitaminosis B₂ were encountered.

The use of skim milk as a supplement to chick rations has been found of unquestioned value in preventing the appearance of "leg weakness" amongst young chicks.

* It was found necessary in this report to alter the dates during which the blood samples were counted, from August-July as in previous reports to October-September. The months of August and September 1934 have not been recorded in either the last report or the above figures, and the number of samples received during this period totalled 27,169.

CIDER.

686 enquiries, including 120 under the Cider Instruction Scheme in the counties of Dorset* and Worcester, received attention during the year. A large number of the requests, 369, came from outside the Bristol Province, and these included a number from abroad, Ireland, Australia, New Zealand, Canada, Kenya, Jersey, France, Mexico, U.S.A., Denmark and Spain all being represented.

In connection with the enquiries, 99 analyses of ciders and various special determinations were carried out. In addition 72 samples of cider apple varieties were received for identification and reports on their vintage qualities.

The subjects of the enquiries for the most part were of a general character as in previous years, but there was a notable increase in the number of applications from farm cider makers for advice regarding the installation of up-to-date cider making machinery and accessories. Sterilization and carbonating of cider are apparently being adopted to increasing extents among farmer cider makers.

The number of applications for advice on matters of a technical nature, both chemical and bacteriological, has shown a considerable increase, many of the problems being of a complex character.

The following problems were of special interest: Intermittent cloudiness in bottled cider and non-alcoholic apple juice which was traced to the use of formalin in excessive quantities for sterilizing bottles, etc.; secondary fermentation in bottle due to faulty steaming of casks and the use of untreated sugar syrup; loss of colour in cask cider caused by exceptionally low acidity; the use of specific yeasts for high alcohol production for which a French distilling yeast was recommended; the use of mustard as a preservative in cider.

Worcestershire participated in the Cider Instruction Scheme throughout the year, whilst Dorset re-entered the scheme in May.

The Cider Instructor paid 107 visits to farms, 27 in Dorset and 80 in Worcestershire, to deal with problems of cider-making and cider orcharding.

In Dorset, special attention was given to cider-making in North Dorset, where the industry is not so advanced as in the west of the country, and to orcharding problems throughout the country.

* Dorset for the period May–September inclusive only.

In Worcestershire, the interest of farmers in cider orcharding has continued to develop. Following the large apple crop of 1934 special attention was given to the use of culls for cider-making and large quantities of cull desserts were successfully utilised for cider-making.

POMOLOGY.

425 enquiries were received, of which 207 were from areas outside of the Bristol Province. The total shows a decrease of 195 from the previous year's record of 620, doubtless due to the abnormally heavy crops in 1934 and the sparsity of fruit in 1935 caused by the disastrous May frost.

Enquiries from overseas were received from Australia, Canada, New Zealand, S. Africa, Tanganyika, Tasmania, France, Germany, Japan and U.S.A.

50 visits to farms were paid in dealing with enquiries.

The range of subjects covered by the enquiries has been very wide, but problems relating to spraying technique, strawberry cultivation and miscellaneous points connected with the establishment of new plantations have been of special importance. Pruning, rootstocks and varieties and problems relating to farm orcharding and cider orchards formed the subjects of many inquiries.

The number of visitors and organised parties to the Research Station has been maintained at a very high level, and the work of the Institute has been demonstrated to these by the pomological staff.

HORTICULTURAL CHEMISTRY.

129 enquiries, including 52 from sources outside the Province, were received. Overseas enquiries emanated from Canada, Irish Free State, New Zealand, Tanganyika, S. Africa and Argentine.

The subjects of enquiry were generally similar to those of previous years, a large proportion relating to problems of fruit tree nutrition and storage, subjects specially studied at Long Ashton.

The requests relating to fruit manuring show that many growers are recognising the importance of manuring in the production of high-grade produce, and in many cases very comprehensive and detailed schemes have been submitted for criticism.

The number of enquiries relating to the establishment of new fruit plantations demonstrates that fruit planting is still actively

continuing, especially of dessert apples, and in several cases advice has been given regarding the establishment of completely new fruit farms.

Cases of failures of fruit trees and garden crops have been fairly numerous and in most of these attention to manuring, drainage and points of management has resulted in substantial improvements. Many of the cases relating to fruit show that advice previous to or shortly after planting would have prevented the failures.

The exceptional climatic features of the 1935 season—the disastrous May frosts and the abnormally dry summer—resulted in several outstanding problems—especially in apples—frost injury to fruits, blotching of foliage following frost effects, and the physiological troubles of Cork, Water Core and Bitter Pit resulting from high temperatures. The prevalence of “Blotchy Cork” (*i.e.* Tree Pit) was especially severe in the variety Newton Wonder, in one or two cases examined almost the whole crops of heavily laden trees being affected. This problem is receiving special attention in the research programme at Long Ashton.

It is evident from the enquiries relating to apple storage and quality that many growers are now considering seriously the use of gas and cold storage methods, and it seems evident that a season or two of satisfactory crops will result in considerable developments in the use of these methods.

Enquiries received relating to glass house crops indicate that in hot, dry seasons such as 1934, 1935, the conditions give rise to special nutritional problems in such crops as tomatoes, especially in regard to ripening. The solution of many of these problems is likely to be found in the correct use of nitrogenous and potassic fertilisers, but it is, of course, impossible to foretell the occurrence of the weather conditions. It is important, however, for growers to recognise the effects of the special climatic conditions in such cases as they often give cause for alarm.

Investigations in Progress.

1. *Experiments on the Control of Lime-induced Chlorosis in Apples, Pears and Plums—in Somerset and Worcester.* The older experiments have been continued and further trees were treated by the ferric citrate injection method in February, 1934. Results from injection continue to be good, although of a temporary character.

2. *Manurial Experiments on Apples and Black Currants—in Gloucestershire and Herefordshire.* In the Gloucestershire experi-

ment the effects of manures are being examined on black currants and apples on an old orchard site where organic matter has become seriously depleted and tree failures have occurred.

In the Hereford trials the effects of potash manuring on dessert apples are under investigation on a site hitherto regarded as unsuitable for fruit growing.

3. *Manurial Experiments on Asparagus—in Worcestershire.* Comprehensive experiments have been carried out at the County Experimental Station at Perdiswell and on a commercial holding in the Evesham area. The trials will be continued over several seasons.

4. *Survey of Soils on the Lower Lias Formation.* The report on the Evesham Area has been completed and mapping has been continued in Somerset.

ECONOMIC ENTOMOLOGY.

The number of enquiries received was 590, which was 239 less than in the previous year. Personal visits of the adviser totalled 266.

The main subjects of enquiry related to the following:—The failure of winter washes to control Plum Aphid: Plum Sawfly, Apple Sawfly, Red Spider, Codling Moth, *Phyllobius* weevils; *Tarsonemus fragariae* on strawberries; Flea Beetles on root crops; Eelworms on various crops.

The main investigations in progress were as follows:—

Combined Summer Washes.

Experimental work was continued on the application of various combined washes at the different stages of apple blossom and fruit development. The combined wash of white oil emulsion and lime sulphur provided a satisfactory control of apple capsid, provided it was applied at the correct stage of egg development.

Mineral oils of different degrees of refinement were tested for their suitability of application to currant foliage.

Rotenone Containing Washes.

Laboratory and field experiments were carried out with rotenone containing washes as means of controlling Apple Sawfly and Apple Capsid. Methods of chemical and biological evaluation of rotenone preparations were continued.

Winter Washes.

Biological studies of winter washes were continued and of those materials examined lauryl rhodanate provided a complete control of aphid eggs.

Action of Insecticides on Apple Sawfly.

Investigations showed that nicotine did not act as an ovicide but was a stomach poison to the young larvae. Rotenone also functioned in a similar manner.

Woolly Aphid.

A white oil emulsion containing nicotine was the most satisfactory spray material for the control of the pest. Preliminary experiments on the hot water treatment of nursery trees were satisfactory.

Plum Sawfly and Red Spider.

It was shown that carefully timed applications of nicotine and arsenate washes did not provide a satisfactory control of the pest. Derris was the most satisfactory wash.

Fruit Tree Red Spider.

Investigations were carried out to elucidate the best time of control. A range of winter and summer washes were tested.

The Control of Pear Midge.

Field trials to test the efficacy of a pre-blossom derris wash were defeated by the severe late frosts at two centres. At the third, the results were not satisfactory.

Eelworms.

(a) *The Behaviour and Control of Heterodera schachtii.*

Calcium cyanamide was again successful as regards plant growth and crop, although the eelworm infestations were not apparently much reduced. This part of the work is in conjunction with the Advisory Mycologist.

(b) *The Oat Eelworm (Anguillulina dipsaci).*

Investigations and observations were commenced with a view to determining the part played by the use of seed from infested crops in causing a spread of the pest.

Flea Beetles.

Extensive field trials were continued with a special seed dressing, and satisfactory results were obtained despite the very adverse field conditions prevailing. The cost of the treatment is very low.

Survey of the Pests and Diseases of Sugar Beet.

Advisory Officers took part in this work at the request of the Ministry of Agriculture. The Adviser made 44 visits in the period covered by this report. The chief pests noted were *Aphis rumicis*, Pigmy Mangold Beetle (*Armarea Linearis*) and "Cutworms" (Agrotid larvae).

Control of Wireworm in Field Crops.

A series of field trials to test the value of calcium cyanamide in this connection was arranged.

The Incidence and Control of Lettuce Aphis.

This work is being undertaken in relation to Lettuce Mosaic in conjunction with the Advisory Mycologist.

The Cause of "gadding" in Cattle.

These observations (undertaken at the request of the Ministry of Agriculture) were continued, and a report submitted. It is considered that in the area under observation the trouble is due to the blood-sucking fly *Haematopota pluvialis*.

Willow Pests.

The biology and control of the beetle *Melasoma populi*, a pest of basket willows, were investigated.

ECONOMIC MYCOLOGY.

395 enquiries were received, compared with 396 last season. Frost injury in May, with a consequent loss of the fruit crop, resulted in few enquiries relating to fruit.

The following is a brief summary of the more important investigational work carried out during the period under review.

Fruit.

Apple Diebacks, Fruit Spots and Fruit Rots.

A preliminary paper was published on the fungi occurring on

apple twigs and branches and their relation to apple fruit diseases. The fungus *Diaporthe perniciosa* has been studied recently from this aspect.

Strawberry Root Rots.

Inoculations of many fungi isolated from strawberry root rots failed to produce rotting as it occurs in the field.

Miscellaneous Strawberry Diseases.

Work is in progress on the "Crinkle" disease of strawberries.

Hot water treated runners of several varieties planted in greenhouse beds of soil from badly infected "Crimp" fields in the Cheddar area developed severe "Crimp" and "Red Plant" while control beds remained practically free.

Vegetables.

Investigations on vegetable diseases were continued with the assistance of P. W. Brian and have been reported on in various publications.

Selections of apparently resistant strains were continued in the case of White Tip of leeks and Foot Rot of dwarf beans.

Lettuce Diseases.

Attention was concentrated during the year on diseases of lettuce. The classification of lettuce varieties has been studied by P. W. Brian, and it has been found that certain groups of lettuces show up mosaic symptoms much less than others.

It has again been found that certain commercial varieties are much more susceptible to *Marssonina* and *Botrytis* than others.

Mint Rust.

Complete control of Mint Rust (*Puccinia Menthae*) in forced mint has been achieved by treatment of the runners with water at 112°F. for ten minutes prior to planting. Two apparently resistant strains of *Mentha villosa-nervata* are under trial.

Pea and Potato "Sickness."

Trials in co-operation with C. L. Walton have shown that heavy applications of calcium cyanamide enable plants to produce normal yields in soil heavily infested with *Heterodera schachtii*, but there is no appreciable reduction in eelworm infestation of the roots.

Tomato Viruses.

Two new tomato viruses have been discovered in the Province and have been investigated in detail by Dr. K. M. Smith.

Ornamentals.

Resistant Antirrhinum and Aster Varieties.

Strains of "rust proof" antirrhinums obtained from California proved highly resistant to *Puccinia Antirrhini*, while American resistant varieties of asters continued to be highly resistant to aster wilt.

Lily Diseases.

A paper on diseases of the Easter Lily has been published. A *Phytophthora* disease new to England, a rot associated with *Cylindrocarpon radicicola* and a physiological flower splitting were under observation.

Hops.

Sclerotinia Wilt.

An epidemic of *Sclerotinia Sclerotiorum* on hops occurred in Herefordshire and Worcestershire in June and July. This was associated with frost injury on May 17th and with infection of weeds in headlands, spores produced from apothecia blowing over the yards and infecting frost-injured vines and weeds. Growers were advised to uncover earthed-up vines and to cut out infected ones.

Virus Diseases.

Field observations were made on the split-leaf complex of hops, while the agents of spread of this and other virus diseases of hops are being investigated in co-operation with Dr. C. L. Walton.

INSECTICIDES AND FUNGICIDES.

The number of enquiries received during the year was 108, of which 77 were from areas outside of the Bristol Province.

The majority of the requests were from commercial firms interested in spray materials, the remainder being submitted by growers and county advisory officers. 55 samples of spray materials were analysed in dealing with the various problems, mainly tar and petroleum oil preparations and "spreaders," together with a few miscellaneous insecticides and fungicides. During the year interviews were accorded on 25 occasions to growers and to representatives of 18 different commercial firms.

FRUIT PRODUCTS.

302 applications for advice were received, of which 257 came from outside of the Province, mainly from London, although most of the fruit growing counties were represented.

Enquiries from abroad came from Ireland, Canada, India, and U.S.A.

The subjects of enquiry may be divided into two broad categories, viz.: general methods and necessary plant for manufacturing products and the commercial possibilities of the various products; detailed advice on the preparation of a variety of particular products, such as syrups, wines and squashes.

A special exhibit of products was staged at the Imperial Fruit Show at Leicester. Numerous visitors interested in products have been received at Long Ashton, whole day visits being paid by 27 persons.

Technical Officers from the Government Departments for Agriculture of Canada, Iraq and Sweden, and a County Officer from Devon spent periods of instruction of about one month in the products laboratory.

Experiments were carried out with a representative of an Australian Fruit Growing Company on the concentration of apple juice.

DOMESTIC PRESERVATION OF FRUIT AND VEGETABLES.

160 enquiries were answered during the year in comparison with 229 last year.

136 enquiries came from outside the Bristol Province, including 6 from Scotland, 2 from Australia and the Irish Free State, and 1 each from S. Africa and Germany.

The fall in numbers was anticipated and can be accounted for by the fact that many more county authorities now employ trained officers in this work so that enquiries can usually be answered locally.

Advice was given in regard to bottling or canning of vegetables and mushrooms, use of sulphur dioxide as a preservative, prevention of mould in jams, wax cartons for jams, the use of colouring matter and preserves, pickling, preservation of tomato juice, candying, drying herbs and fruit, mint jelly, equipment for preserving, judging preserved produce.

Lectures, Demonstrations and Classes.

These were held at the following centres :—

Lectures and Demonstrations : Liverpool, London, Cirencester, Folkestone, Exeter.

Classes : Preston, Lancaster, Sparsholt, Chelford, Chester, Studley.

Courses of Instruction.

Three courses in Fruit and Vegetable Preservation were held at the Royal Agricultural College, Cirencester, from July 23rd to August 30th. In all 46 students attended the courses.

General.

Judging of produce was undertaken at the British Dairy Farmers' Association Show in London and at Women's Institute Produce Exhibitions at Gloucester, Dorchester, Folkestone, Oxford, Norwich, and Newcastle.

Close co-operation with the National Federation Women's Institutes has been maintained and, as last year, the instructress has served on the Agricultural Sub-Committee of this body and also on the Executive Committee of the Gloucestershire Federation Women's Institutes.

At the request of the Ministry of Agriculture material for a Fourth Edition of Bulletin 21 "Domestic Preservation of Fruit and Vegetables" was prepared.

WILLOW GROWING.

275 enquiries were made, of which 139 were from areas outside the Bristol Province.

Information was required on methods of preparing land for the crop, suitable varieties for planting, cultivation problems and on the restoration of derelict willow land.

New willow beds have been planted in Lincolnshire for the growing of willows specially suitable for making baskets for the fishing industry and in Norfolk with the object of growing rods specially suitable for the Blind Institution of the country whose annual requirements appear to be about 1,000 tons.

The River Great Ouse Catchment Board's requirement in willow rods for embankment work amount to about 800 tons yearly, the quantity being now supplied by this country in place of Holland.

The Cricket Bat Willow continues to be planted in great number ; the importance of planting good sets is becoming more fully recognised as essential to commercial success.

PUBLICATIONS, 1935.

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